

C O N T E N T S.

Agricultural bulletins and Reports.  
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6. The Palm Beetles in Burma. By C.C.Ghosh. (Bulletin No.19). 1923. J:A385.238 pp.117-144.

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7. Studies on the Rice Plant and on Rice Cultivation. 1930. J381.231 pp.147-194.
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10.        dto. Agricultural Experiment Stations, Assam, ending 30th June 1912. J.261/3 pp.243-274.
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12. Land Crabs as Agricultural Pests in western India. J: 438.231 pp. 319-350.
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DEPARTMENT OF LAND RECORDS AND AGRICULTURE,  
ASSAM.

BULLETIN No. 1 OF 1914.

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PRESERVING FODDER FOR WINTER IN  
THE KHASI HILLS.

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J2:72:8.261



SHILLONG :

PRINTED AT THE ASSAM SECRETARIAT PRINTING OFFICE.

1914.

DEPARTMENT OF LAND RECORDS AND AGRICULTURE, ASSAM.

Bulletin No. 1 of 1914.

PRESERVING FODDER FOR WINTER IN THE KHASI HILLS.

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The cattle on the plateau of the Khasi and Jaintia Hills suffer much for want of fodder during the winter when green grass is not available, and many even die for want of food. We should like to see people grow special crops—what are called fodder crops—for feeding their cattle; but even if they would not do that, they might with a little trouble preserve such fodder as they now possess and utilise it for feeding cattle in winter rather than allow it to go to waste as is now the case. In this leaflet we describe an easy method of preserving green fodder and we should be glad to see the cultivators give it a fair trial. Information and advice can always be had from the Deputy Director of Agriculture, the Superintendent of the Upper Shillong Farm or the District Agricultural Officer, Khasi and Jaintia Hills.

2. The method consists in burying green fodder at any time during the rainy season from June to September in an underground pit (technically called a silo) and keeping it covered with a thick layer of earth until such time as it is wanted for use. Fodder thus preserved is known as silage for which there is no corresponding word in the Khasi language. It remains as succulent as green grass and if well made, it has a sweet pleasant smell which the cattle soon get to like.

3. All kinds of wild grass that the cattle eat can be preserved in this way. Large quantities of these can be had in the rains for the mere trouble of gathering them. Among cultivated plants, maize and Job's tears while they are still green would be excellent material for a silo, but few cultivators would be willing to sacrifice these crops for the sake of fodder. The straw of Job's tears gets too hard and dry by the time the grain is ripe for harvest, and nothing will be gained by burying such straw in a pit. But with maize, the case is different. This crop leaves a considerable quantity of stalks and leaves after the ripe cobs have been gathered. No use is made at present of these stalks and leaves, but if they are chopped up and put into a silo, they would make a fairly good silage. It will not of course be as good as silage prepared from the entire maize crop, that is, with the cobs, stalks and leaves all taken in.

4. The pit should be dug on high and well drained ground say at the top of a hill slope. The sides and bottom should be quite dry ; if water percolates through, it will cause the fodder to rot. There should be a roof over the pit to prevent rain water from soaking through the top covering of earth and penetrating the interior of the silo.

The pit should preferably be circular in shape. The size should depend upon the quantity of fodder to be stored. The larger it is the better. There is always a certain amount of fodder at the top and sides of the pit, and occasionally also at the bottom, that is found on opening the silo to have rotted and become useless. Such wastage is proportionately greater in a small silo than in a large one. Where possible, two or more villagers may combine with mutual advantage to make a silo and to divide the contents in winter according to the amount of fodder they respectively put in.

A pit 10 feet in diameter and 8 feet deep should contain (after allowing for loss of a layer of fodder 6 inches thick all round) about two hundred maunds of silage. One maund of silage, if supplemented by such meagre pasturage as is available in winter, should provide sufficient food for 6 heads of Khasi cattle for a day. Taking the winter to last for 4 months or 120 days the 200 maunds of silage should give a daily ration of  $1\frac{2}{3}$  maunds which will carry 10 heads of cattle through the winter.

5. It is always preferable to chop up the fodder whatever it is, before putting it into the silo. This is indispensable in the case of maize. When chopped the mass packs more compactly in the silo and air is thus excluded more effectually than would be the case otherwise.

6. The time for filling a silo depends on when the crop to be used is ready. With wild grass the proper time is after the grass has flowered and before it has become too coarse. This would be July or August in the case of the majority of wild grasses in the Khasi Hills. With Indian corn, if the entire plant *i.e.*, stalk, leaf and cob, is to be used, it should be cut when the grain is in the "dough" stage, that is to say when the grain is neither too soft and milky nor yet too hard. In the Khasi Hills, the crop reaches this stage generally in August. When only the stalks and leaves are to be used, another month at least must elapse.

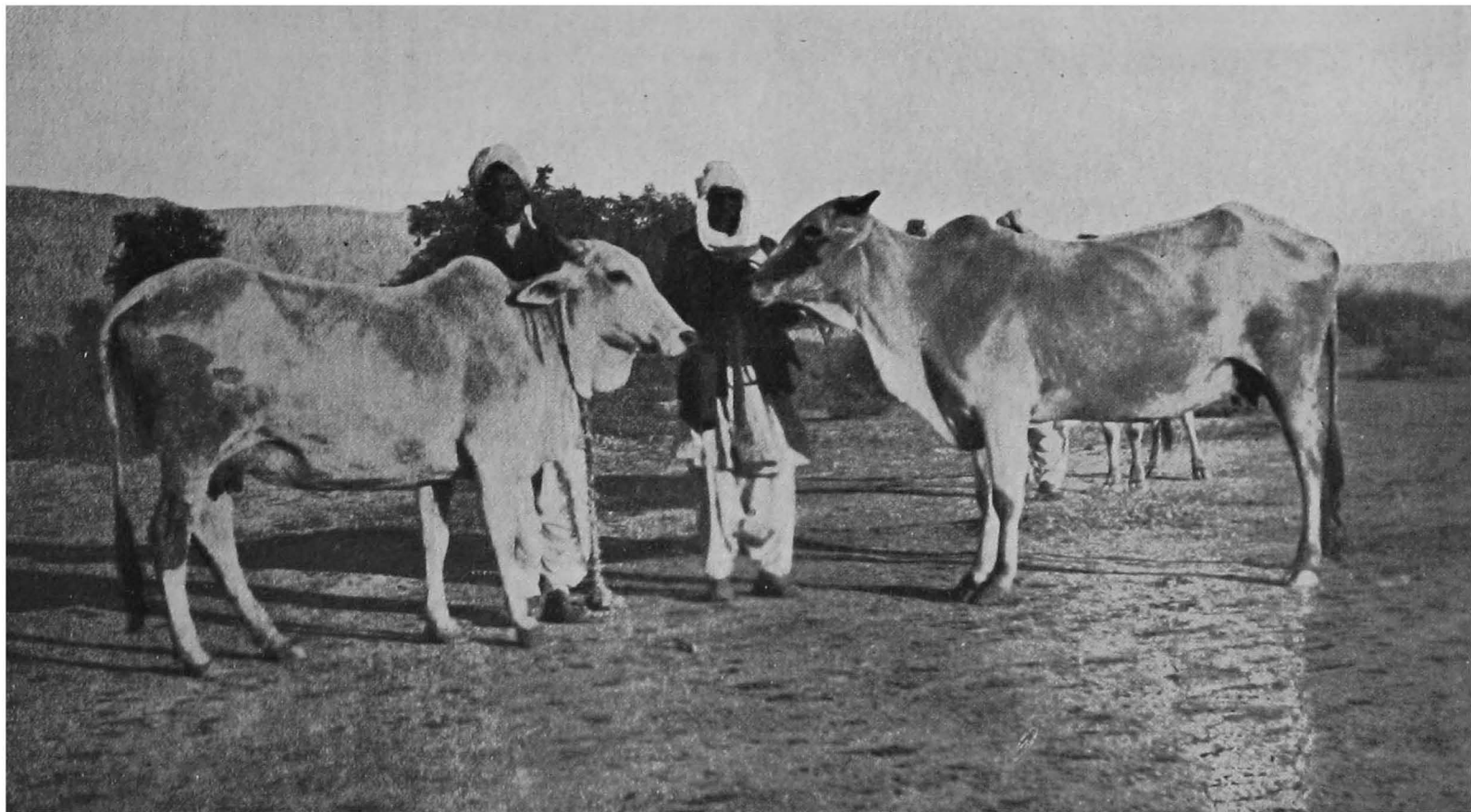
7. The filling of the silo should be done gradually (say) in three or four instalments with intervals of two or three days between them. After each day's filling the fodder should be spread even and lightly pressed down and some logs of wood placed on the top. The object is to induce fermentation in the mass, which be-

comes quite heated in the course of two or three days, so much so that if the hand were thrust into it, it would feel uncomfortably hot. As soon as this is found to be the case, when also the mass will have sunk down, a fresh layer of material should be put on and pressed down as before. After the final layer has been put on, it should be allowed to heat for two or three days, then the silo should be finally closed and weighted down with a thick covering of earth, 18 inches or 2 feet deep. If the earth sinks and cracks too much in consequence of the shrinking of the fodder, a fresh layer of earth may have to be added later on. To reduce the wastage of fodder through rotting, it is a good plan to place a layer of common grass at the sides, top and bottom of the silo and to put the fodder proper in the centre. The loss thus falls on the outer layer of grass which was not intended for fodder.

8. Good silage prepared in the manner described above should have a pleasant smell and should be sweet, and not sour. It will be fit for use after six weeks and will remain good practically for as long as the owner chooses to keep it. It can be kept a year, or even two years, if desired. If the fodder be not pressed well or if air gains access to the interior, the silage will be sour and smell of vinegar. Sour silage is not so well relished by cattle as sweet silage, and some cattle may refuse to eat it. The unpleasant sour smell disappears in large measure by exposing the silage to the open air for a short time. To induce cattle to take to silage, a little salt may be sprinkled on it for a day or two in the beginning.

9. In European countries, fodder crops are generally preserved by drying in the sun, that is, by turning them into hay. But during wet weather, and particularly in our wet climate, this is not possible. Besides, such coarse-stemmed crops as maize lose much of their value as fodder by drying. On the other hand, when preserved in a silo, it remains succulent and is eaten by cattle with relish, and herein lies the advantage of the silo over hay-making. Silage is like food that has been cooked. The finer grasses, e.g., *Raishan* which remains green till October may be cut and dried for hay. A great deal of *Raishan* hay is made annually in the Upper Shillong Farm for feeding cattle in winter, and it has proved to be excellent stuff for feeding all classes of stock on during the winter months.

Shillong, }  
 The 19th November 1914. } Special Officer, Agricultural  
 Department, Assam.



Two young Bhagnari cows.

DEPARTMENT OF LAND RECORDS AND AGRICULTURE,  
ASSAM.

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BULLETIN No. 2 OF 1914.

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BORDEAUX MIXTURE AS A PREVENTIVE  
OF THE POTATO DISEASE.

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DEPARTMENT OF LAND RECORDS AND AGRICULTURE; ASSAM.

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BULLETIN No. 2 OF 1914.

BORDEAUX MIXTURE AS A PREVENTIVE OF THE POTATO DISEASE.

Bordeaux mixture is a mixture of copper sulphate and lime with water. It is very useful for checking the serious disease of the potato crop which is known to Khasia cultivators as the black disease or *pang-iong*. When attacked by this disease the leaves and, later on, the stem of the plant turn black and soon the plant dies. The crop has therefore to be harvested weeks before it attains maturity, and the yield is consequently less than it should be. Many of the tubers also get diseased. On cutting them open, signs of the disease will be seen in the black or brown stains in the flesh. Such diseased tubers are liable to rot if kept. If they are cooked before they become rotten, the diseased portions will be found to be hard and inedible.

2. This black disease of the potato has caused great losses in the Khasi Hills. The disease is favoured by wet weather. The spores or germs of the fungus which causes the disease require moisture for germination; hence the crop of potatoes which is grown in the rainy season in the Khasi Hills is excessively subject to the disease, while the autumn crop which occupies the field from September to November is seldom attacked. For a similar reason, in the plains where the potato crop is raised during the dry season, the disease does not easily spread from plant to plant, and is usually to be found only in such plants as have been produced from diseased sets.

3. If a leaf of a potato plant is moistened with Bordeaux mixture, it gets coated with a thin layer of copper sulphate which, being a poison, prevents the spores of the fungus of the disease from germinating. Herein lies the preventive action of the mixture. The object of adding lime is to neutralize the caustic effect of copper sulphate which, but for lime, would burn the leaves.

4. Repeated experience at the Government Farms at Upper Shillong and Umlyngka has shown that Bordeaux mixture is very effective in checking the potato disease. It cannot entirely

prevent the disease, but greatly reduces the injury caused by it and thereby enables the plants to live a fortnight or a month longer than they otherwise would, and thus increases the yield of the crop. I will quote the results of two experiments made in the season of 1907. In one, two equal plots of summer potatoes, each  $\frac{1}{40}$ th of an acre, were contrasted. One of the two plots was sprayed with Bordeaux mixture three times during the season, the total quantity of the mixture used being  $7\frac{1}{2}$  gallons =  $37\frac{1}{2}$  seers. (This is equivalent to 300 gallons or  $37\frac{1}{2}$  maunds per acre of Bordeaux mixture, the cost of which is Rs. 21-14-0 per acre inclusive of the cost of spraying.) The other plot was not sprayed at all. In the second experiment two equal plots of summer potatoes were taken; one received 300 gallons of the mixture per acre and the other received none. The yields of potatoes in the two experiments and the profits obtained from the use of Bordeaux mixture were as follows:—

Treatment.	Yield of potatoes per acre.	Increase of yield due to spraying per acre.	Value of increase at Rs. 2 per maund.	Cost of spraying per acre.	Profit due to spraying per acre.
1	2	3	4	5	6
<i>First Experiment.</i>					
Sprayed with Bordeaux mixture 300 gallons per acre.	Mds. 241	Mds. 55	Rs. 110	Rs. s. p. 21 14 0	Rs. s. p. 88 2 0
Unsprayed ... ..	186	...	...	...	...
<i>Second Experiment.</i>					
Sprayed with Bordeaux mixture 300 gallons per acre.	329	104	208	21 14 0	186 2 0
Unsprayed ... ..	225	...	...	...	...

These figures show what wonderful results can be expected from the use of Bordeaux mixture. Similar experiments made in previous years also gave similar results, and in every case the use of Bordeaux mixture gave a substantial profit.

5. Bordeaux mixture is prepared as follows:—Put 16 gallons or 2 maunds of water into a large tub. Take out 5 to 10 seers and in this suspend a bag containing one seer of copper sulphate. By the next morning all the crystals will have dissolved. Then,

take 12 chattaks of unslaked lime (*i.e.*, freshly burnt lime which has not absorbed water), and slake this carefully with a little water and work it to a smooth paste. One seer of paste lime ordinarily used for whitewashing may be used in place of freshly burnt lime. Add 5 to 10 seers of water (about the same quantity as was used for dissolving the copper sulphate) to the lime and mix thoroughly. Now pour the copper sulphate and the lime mixture into the tub stirring continually (the lime must be strained through a coarse cloth). Leave this mixture to stand for a few minutes. On examination a bluish white precipitate will be noticed under the clear water. Now it is very important to see whether sufficient lime has been put into the mixture to neutralize the scorching effect of the copper sulphate, and this is easily seen by dipping the clean blade of a knife for a minute or two in the clear liquid at the top. Should there be a reddish deposit indicating copper on the blade, then the copper sulphate is not fully neutralized, and more lime mixture must be added until no deposit of copper appears on the blade. For adding this some spare mixture must be prepared and kept ready (about  $\frac{1}{4}$  seer of unslaked lime) in a separate pot, but if the lime is fairly pure,  $\frac{2}{3}$  seer or even  $\frac{3}{4}$  seer will be found sufficient for neutralizing one seer of copper sulphate.

Thus you have water—

Two maunds or 16 gallons.

Copper sulphate 1 seer.

Unslaked lime  $\frac{3}{4}$  „

and the cost will be—

			Rs.	a.	p.
Copper sulphate 1 seer	...	...	1	0	0
Lime $\frac{3}{4}$ seer	...	...	0	1	0
Labour for preparing and spraying	...	...	0	2	0
			<hr/>		
Total	...	...	1	3	0
			<hr/>		

6. The mixture should be prepared on the very day that it is required for application. The copper sulphate solution can be kept as long as you like, but the lime mixture as well as the Bordeaux mixture itself cannot be kept good longer than a few hours. Copper sulphate has a corrosive action on the common metals; metallic vessels cannot therefore be used for dissolving it, or for preparing the Bordeaux mixture.

7. Now, as to the method of spraying the mixture over the potato crop. There are specially designed pumps for spraying Bordeaux mixture and other liquids used for checking various insect and fungus pests. The kind of spraying machine we use on our Farms is known as the "Pilter" pump; the machine holds 4 gallons or  $\frac{1}{4}$  a maund of liquid and cost about Rs. 30. It is perhaps too expensive to suit the means of small cultivators, but if several raiyats combine together and contribute a few rupees each, they should be able to purchase it without difficulty. A stock of pumps and copper sulphate is kept at the Upper Shillong Farm for sale at cost price to the cultivators.

8. The oftener the potato crop is sprayed with Bordeaux mixture, the better it will be. In practice, we have found it convenient to spray twice, once as soon as all the sets have germinated and the young plants have come up well above ground, say about the middle of April, a second time a month or five weeks about the end of May or beginning of June. These dates apply to the higher plateaux of the Khasi Hills. About Cherrapunjee the dates would be about a month earlier. At each spraying, 120 gallons=15 maunds of the mixture may be used per acre.

9. Fine settled weather should be selected for spraying work. Rain following soon after the application of the mixture would wash it off the leaves, and thus reduce the good effect of the operation.

10. There are numerous other fungus diseases like the black disease of potatoes which attack other plants and destroy them. For most of such diseases, Bordeaux mixture is the best practical remedy. It is expected to be useful as a remedy for the well known blight of the betel leaf.

*Shillong;*

*The 19th November 1914.*

**B. C. BASU,**

*Special Officer, Agricultural  
Department, Assam.*

DEPARTMENT OF LAND RECORDS AND AGRICULTURE,  
ASSAM.

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BULLETIN No. 3 OF 1914.

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POTATO CULTIVATION IN THE  
ASSAM HILLS.

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J341.261



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1914.

DEPARTMENT OF LAND RECORDS AND AGRICULTURE, ASSAM.

Bulletin No. 3 of 1914.

POTATO CULTIVATION IN THE ASSAM HILLS.

These instructions are based upon experience gained at the Upper Shillong Farm which is situated on the higher plateau of the Khasi Hills. They will apply perhaps equally well to the higher regions of the other hill districts of Assam, where the occurrence of frosts renders the cultivation of potatoes impossible as a cold-weather crop such as is possible in the plains of Assam and of Northern India generally. The higher plateaux of the Khasi Hills constitute at present the only hill tract where potatoes are grown as a staple crop. The crop has begun to be cultivated to a small extent in the other hill districts. Where facilities for transport exist, it will pay well to grow potatoes for export. But apart from its commercial value, potatoes may with great profit be grown as a staple food of the people. It is extensively consumed as such by the Khasias.

2. In the higher hills, it is possible to grow potatoes twice in the year, namely, once in summer and a second time in the autumn. The summer crop, which is the main one, is planted early in the spring—between the end of January and the end of March according to the warmth of the atmosphere—and harvested four or five months later. The autumn crop is planted in July and August and taken up in the winter. It does not get time enough to reach maturity, being killed out by frost several weeks before it is due to ripen. The yield of the autumn crop is consequently very low. Its main purpose is to furnish seed for the following summer crop, and very little of its produce is ordinarily available for sale.

Paragraphs 3 to 11 refer to the cultivation of the summer crop and paragraph 12 to that of the autumn crop.

3. Two distinct methods of growing potatoes can be pursued in the hill districts. One may be called the garden system and the other the *jhum* system. The latter is possible only in localities where waste lands abound as they usually do in most hilly places.

Two methods of cultivation.

In the garden system, the same land may be cultivated with potatoes year after year, and the crop is invariably manured. In the *jhum* system, on the other hand, new waste land is used every year, and not more than one crop of potatoes is taken during the two or three years that it remains under cultivation.

The garden system yields larger tubers and much heavier outturns than the *jhum* system, and is the method which ought to be followed, wherever possible. The *jhum* system is an extremely wasteful method of cultivation and is permissible only where waste land and jungle growth are plentiful and admit of no other use. *Jhum*-grown potatoes, however, possess a special merit in that the tubers, though smaller in size, are firmer in texture and more free from disease than those obtained from garden cultivation, and are for these reasons preferred for use as seed.

4. Light, loamy soils which are easily cultivated and readily fall into powder are the best suited for potatoes.  
Soil. Most soils occurring on hill slopes are usually of this description. Land having an excessive proportion of gravel or stones is difficult to cultivate and should be avoided. Potatoes do not grow well on clay soil, but such soil is rarely to be found on the hills.

5. In the garden system of cultivation, the preparation of the land should begin in the autumn, say in October or early part of November. It should be given, to start with, a deep ploughing or a digging with the spade, and thereafter two or three more light ploughings or hoeings in order to reduce the soil to a fine tilth. The land being cultivated and manured every year will not, as a rule, require any more preliminary cultivation than is indicated above. It is, however, important to stir the soil to a good depth—say 8 inches—in the autumn. It will enable the soil to retain sufficient moisture for germinating the crop, in the event of the spring proving drier than usual; and at the same time by increasing the feeding area for the roots, it will promote the development and outturn of the crop.

For deep cultivation, we recommend the use of an English plough which costs Rs. 50 delivered at Shillong. Two pairs of country bullocks will be required for working this plough. Any cultivators wishing to purchase this plough should apply to the Farm Superintendent, Upper Shillong, or to the Deputy Director of Agriculture, Shillong. For cultivators of small means we would suggest that several club together and purchase a plough.

The method of preparing the land under the *jhum* system of cultivation is as follows:—The land is prepared during the winter by a process of paring and burning of the turf. Brushwood growing on the land or obtained from jungle near by is arranged in long narrow beds, 4 to 6 feet wide, leaving open intervals of about the same width between them. When the wood is dry, the turf is pared off the intervening ground and laid over the wood, and allowed to dry for some days. Shortly before the time for planting arrives, the brushwood with the turf over it is set on fire. In the mixture of burnt earth and ashes thus obtained the potato sets are planted in the same way, as in the garden system of cultivation. No other manure is used.

6. The potato crop requires liberal manuring. Cowdung is practically the only manure ordinarily available in the hill districts. It should be well-rotted and may be used *ad libitum*; a suitable rate would be 300 maunds per acre, but more or less than this may be used according to the quantity available for the purpose. Unless the soil is virgin and very rich it will not pay to grow potatoes without the use of cowdung. Under ordinary conditions, when the supply of cowdung is limited, it may be partially replaced by castor or rapeseed cake, using (say) one maund of rapeseed cake in place of 7 or 8 maunds of cowdung. The addition of 20 maunds of rapeseed cake per acre has been found at Upper Shillong to increase the yield by about 70 maunds per acre. One will be able to calculate from these figures if at the local prices of oil-cake and potatoes it will pay to use this manure.

As already mentioned, *jhum*-grown potatoes receive no manure beyond the ashes obtained from the burning of the brushwood and turf.

7. We have tried numerous varieties of potatoes at the Upper Shillong Farm for comparing their respective merits, and as the result we have found the following English varieties to be the best all round:—

King of potatoes,

Magnum Bonum (which is identical with the variety popularly known as the Nainital),

Windsor Castle and

Up-to-date.

The first two are perhaps the best. We accordingly recommend these two varieties for cultivation in the hill districts. Windsor Castle is a round shaped potato; the others are of a more or less oval shape. All possess a white mealy flesh.



We also recommend that potato growers should import a new stock of seed once in 3, 4, or 5 years.

Cultivators will be able to get seed potatoes of the varieties we recommend either from the Government Seed Depôt at Gauhati or from the Upper Shillong Farm. Nothing more than actual bazar price will be charged. Purchasers will have besides to bear the cost of transport from the Depôt or the Farm to their own place.

8. Care should be taken to ensure that every tuber should carry at least one strong sprout, and any that do not possess one such ought to be discarded. If the seed potatoes are too fresh, they should be kept spread out on a dry floor for a fortnight or three weeks until the buds have shown well above the skin. The sprouts need not be more than one-eighth of an inch long. If too long, they are liable to get broken in the handling.

If the seed tubers be too large, they should be cut into 2 or 3 pieces each bearing a prominent bud or "eye" as it is called. Small tubers should be planted whole. The best size for seed is 32 sets—whether cut or whole—to the seer. An acre of land will require about 12 maunds of seed which has been found to be the most profitable seed-rate at the Upper Shillong Farm.

9. After the land has been brought into a thoroughly good tilth, parallel furrows, about 4 inches deep and 2 feet apart, should be made with the plough or the spade, and the cowdung applied in the furrows. On the top of the cowdung, the potato sets should be placed 6 to 12 inches apart according to size, and the earth drawn over the furrows by the hoe or by hand thereby making the land level or making a slight ridge where the furrow was.

If oil-cake is to be used, it should be well powdered beforehand, and strewn over the cowdung in the furrows, before the sets are put in.

A somewhat different method of planting potatoes obtains in the Khasi Hills. The land is laid out in beds about 8 feet wide and 20 to 30 feet long, with furrows about a foot wide between the beds to facilitate the draining of rain water. The sets are planted in the bed in holes about 18 inches apart each way, and each plant is earthed up separately. We prefer planting in furrows as described above. The soil keeps drier when laid out in alternate furrows and ridges than when it is left more or less flat in a bed.

10. Subsequent operations consist in keeping the land clean by one or more weedings and in earthing up the potatoes once when all the plants are above ground, and a second time a month or so later.

The crop being grown in the rains is liable to suffer from a serious disease which is known among the Khasis as *pang iong* (literally black disease), and in Europe as the potato disease. It is caused by a fungus which spreads by means of invisible spores, and causes the leaves to turn black and rot. The disease spreads with such rapidity that within a week of its appearance it may reduce a whole field of potatoes to the condition of naked stems without any leaves on them. It not only kills the crop before it is due to reach maturity, but the fungus passes through the stem into the underground tubers and causes these to rot. Spraying with a mixture of lime and copper sulphate is an effective remedy for preventing and reducing the ravages of this disease. This mixture is popularly known as "Bordeaux mixture." For a description of the methods of preparing and using this mixture, reference should be made to Leaflet No. 2 of 1914 of the Department.

11. The crop should be harvested after the leaves have turned yellow and the plants have ceased to grow. If the crop happen to be attacked with the potato disease, it will die prematurely and should then be taken up without delay.

A fair yield in the Khasi Hills under ordinary conditions would be from 90 to 120 maunds per acre. In the *jhum* system the outturn is even less. With deeper cultivation and liberal manuring, an outturn of 250 to 300 maunds may be easily obtained.

12. The autumn crop is raised on land from which a summer crop of potatoes has immediately before been taken in the garden system of cultivation. The *jhum* system does not admit of a second crop of potatoes being taken.

For the autumn crop, the land needs no special preparation. The seed is taken from the preceding summer crop. The tubers are kept in the house for 3 or 4 weeks in order to start the buds; when these are well forward, the sets (always whole in this case) are taken out to the field and planted in holes, 6 to 9 inches apart each way, that is to say, much closer to each other than in planting for the summer crop. A much heavier seed-rate—30 to 40 maunds to the acre—is consequently needed. No manure is used. After the plants have come up, the weeds are buried in with a light hoe and the plants earthed up at the same time. A

second hoeing and earthing is seldom necessary. As already mentioned, the crop does not get time to mature, being killed as soon as frosts appear. The tubers remain small and may be harvested any time during the winter at the convenience of the cultivator. The soil being dry at the time, there is no risk of the potatoes rotting in the ground. The outturn of the autumn crop is usually very small, and seldom exceeds twice the quantity of seed tubers planted.

CAMP KABIRGANJ,

*December 2nd, 1914.*

B. C. BASU,

*Special Officer, Agricultural  
Department, Assam.*

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**Department of Agriculture, Bombay.**

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# FODDER CROPS OF WESTERN INDIA

BY

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# FODDER CROPS OF WESTERN INDIA.

## I. INTRODUCTION.

The growing of crops specially and only for the sake of their fodder value is almost a new thing in Western India. Large amounts of fodder for cattle and other animals have, of course, always been grown, but they have been, as it were, a side issue in the growing of grain or other crops. In recent years, however, the matter has taken a new aspect. There is on the one hand a very large demand for fodder from the big centres of population, which has led to the extensive growing of such crops as lucerne, and fodder *jowar*. On the other hand, it is beginning to be recognised that if an animal is expected to do more than live, that is to say, if it is expected to work or to produce milk, better food than can be picked up during a large part of the year by wandering over the bare fields and stony hills of the Deccan and corresponding places in other parts of Western India, or than can be furnished by rice straw or a limited amount of *jowar kaitha*, must be provided. An interest in the growth of purely fodder crops is therefore rising.

The area devoted to these crops in the various districts of the Bombay Presidency (excluding Sind) is, however, still very small, and is most largely made up of *jowar* in the hot weather, of lucerne, of guinea grass to a small extent, and of *jowar* in the rains. This area is, however, rapidly increasing as the following figures will show:—

Area under fodder crops (Bombay Presidency excluding Sind).	
	Acres.
1907-08	... 26,419
1908-09	... 20,766
1909-10	... 21,206
1910-11	... 20,652
1911-12	... 64,216
1912-13	... 96,984
1913-14	... 79,221
1914-15	... 108,793

The area was apparently fairly constant until the Gujarat famine of 1911-12, when it took a sudden increase, which has been more than maintained in the succeeding years.

In Sind the area is remarkably small considering the absolute dryness of the country and the facilities for irrigation. The following are the figures

of area during the last seven years: nine-tenths of the acreage given is in the one district of Thar and Parkar.

Area under fodder crops (Sind).

	Acres.
1907-08	... 12,553
1908-09	... 13,678
1909-10	... 10,726
1910-11	... 8,409
1911-12	... 9,166
1912-13	... 11,232
1913-14	... 13,266
1914-15	... 16,127

The present bulletin is intended to be a compilation of what has at present been found out as to the most suitable fodder crops in various parts of Western India, the parts where each of them are likely to be useful, the methods of growing them which have given the best results, the yield which has been obtained, and the value of the fodder produced. The basis is the information contained in Mollison's Text book of Agriculture, but a very large accumulation of data has occurred since that time both in India and elsewhere, and this has, where suitable, been, as far as possible, incorporated.

Ordinary forage grasses have been excluded from consideration, unless they are grown as special crops, which is not usually the case. The growth of those crops where the fodder produced is only a secondary product is also not dealt with. In compiling the results I have had the co-operation of the Deputy Directors of Agriculture in the Bombay Presidency and staff, the managers of the military dairy farms, the staff of the Poona Agricultural College and others,—and to all of these my best thanks are given, for it is to their information that any value which the bulletin may possess is due.

## II. THE FEATURES OF A GOOD FODDER CROP.

Before describing the crops which have either won their title to the name of fodder crops, or which seem to have possibilities of becoming so in Western India, let us consider shortly the factors which make a given plant successful in this direction. It is not by any means sufficient that a crop should be edible, should be digestible, should be palatable or have any other single one of the many characters which a fodder crop must possess. We have often been urged to grow a plant for food for one or other of these reasons. But there are at least five or six characters, all or nearly all of which must be possessed together if a crop is really to be of value to a farmer as a special fodder crop, to which he is expected to devote any considerable portion of his land.

These characters are as follows :—

1. The crops must be palatable, digestible and not injurious to the animals which are expected to eat them. The palatability is generally



connected with a leafy character, and with succulence of stems and leaves. A large amount of fibre means a less satisfactory fodder,—and hence one has to consider very closely the stage at which a crop should be harvested if it is designed as a fodder crop. Many, among the most usual fodder crops, rapidly increase their content of fibre after a certain stage in their growth, and what was a good fodder before becomes a very inferior one later. Many grasses may be cited as examples. When they flower they are excellent: when they ripen they are barely worth the cost of harvesting. Rice straw is, after the rice has been reaped, an exceedingly poor fodder,—so is wheat straw. And yet in earlier stages these are excellent feed.

Again among our most common fodder crops, there are a number which in certain stages are injurious. This is particularly the case with nearly all our common *jowars* (*sorghum*). Before they flower, the plants are apt to produce hydrocyanic acid (prussic acid) in the body of the animal, more especially if a vigorous growth has been afterwards stunted by any cause whatever. And they are hence very dangerous at this stage. I will discuss this matter when dealing with this group of crops, but the lack of knowledge of the fact has led to the loss of many a valuable animal. Even when not actually poisonous, many of the crops are likely to cause very serious digestive disturbances at certain stages. I have heard of cows being very much injured by getting large quantities of young maize,—or even of young lucerne.

One must know in fact that a crop is palatable, digestible and non-injurious not only at some stage, but at the stage at which it is proposed to use it.

2. A successful fodder crop must grow quickly, so as to allow the land to be used for another crop or for another cutting of the same crop. In this part of India, where, almost universally, the rainy season is short, and where one can only extend the growing season by expensive irrigation,—the necessity of a quick growing crop is particularly great. If it is to be grown on the rain,—it must be ready for cutting by the time the reliable rainfall will probably have ceased. If it is to be grown under irrigation, the cost of a single watering is so great that the necessity for an extra irrigation may mean all the difference between a considerable profit and little or no profit at all. When irrigation is available, the fodder crop has to compete as an occupant of the land with other very valuable crops,—and an extra thirty days in growing may mean that it will not pay as against these other crops.

3. Equally necessary is it that any proposed fodder crop should give a large yield of fodder per acre. Only a limited amount of good land can be devoted to fodder growing,—and land which is not good is rarely satisfactory for most fodder crops, and a maximum yield in a minimum of time is an essential thing. We have, luckily, some fodder crops here which yield as well as any in the world: many of those recommended and used in America or Australia give nothing like the quantity that some of our *jowars* or maize will produce per acre within two or three months. And though there may be occasions when a fine fodder which yields little will pay to grow,—as a rule the maximum quantity obtainable per acre is a very important factor in deciding on the crop.

4. A fodder crop is more likely to be successful if it does not need high manuring. As a rule, however, fodder crops grown intensively do need good manuring and well cultivated land,—but if one crop or one rotation of crops needs less manure than another, it is a vital factor in its success. But while this is true, I want specially to insist that usually fodder crops do need well

tilled, well prepared, and well manured land. A great necessity for success in this direction is the recognition of this fact. Much has been talked recently about dairy farms—which are likely to be, of course, largely fodder farms. These will only have even a probability of success if it is recognised that the growing of fodder represents a high type of intensive agriculture.

5. It is generally also very important that the crop chosen should be one which can be preserved without serious deterioration. A crop which can only be used as it grows or which deteriorates much if not used at once, is badly handicapped with another, even yielding less per acre, which can be preserved as hay or silage for the drier parts of the year. I believe myself that the future of cattle maintenance in Western India lies largely in the development of silage making,—and if this is so, the importance of the point on which I am now insisting becomes obvious.

A good fodder crop then—

(1) should be palatable, digestible and non-injurious at the stage at which it is to be fed ;

(2) should occupy the land (for one crop) for as short a time as possible, more especially if grown under irrigation ;

(3) should yield as large a crop of fodder per acre as possible ;

(4) should need as little high tillage and manuring as possible,—even though good fodder crops as a rule do need fairly high tillage and manuring ;

(5) should be capable of being preserved, generally as silage or hay, without serious deterioration.

We will now consider the fodder crops hitherto used with success in Western India and how they respond to these demands.

### III. JOWAR OR SORGHUM.

Of all the plants grown in the world for the production of fodder, *jowar* (*Andropogon sorghum*) probably stands first in being capable under a great variety of conditions of producing a very large quantity of palatable fodder in a minimum of time and under fairly dry conditions. It is, of course, a tropical or semi-tropical plant,—and its varieties are grown all over the tropical and sub-tropical regions of the old world. But in most of these regions it is only incidentally a fodder crop, and its principal use is in the production of grain. In America, however, its use as a fodder crop has been thoroughly appreciated and by far the largest proportion there is grown purely for the purpose of feeding to animals either green, or as silage, or as hay.

#### *Climate required for Jowar.*

*Jowar* exists in many varieties, but in general it may be said that all these, whether grown for grain or for fodder, require a fairly warm climate, and also a fairly dry one. In India its cultivation gradually disappears when the rainfall is much greater than forty inches per annum, and also when the temperature during the time of growth becomes low. In regions of heavy rainfall *jowar* is replaced by rice as a grain crop, partly because rice yields a better financial return, but partly also because the wet condi-

tions are unsuitable to the crop. This is well illustrated by the following figures of the percentage of the total cultivated area under this crop (whether for grain or otherwise), placed side by side with the rainfall in various talukas of one or two districts, and in the whole of other districts in the Bombay Presidency \* :—

District.	Talukas.	Average Rainfall.	Percentage of total cultivated area under <i>jowar</i> .	Percentage of cereal acreage under <i>jowar</i> .
		Inches.		
Poona	Haveli	31.9 (Poona)	14.1	28.9
	Sirur	21.7	25.9	39.1
	Bhimthadi	23.8	39.8	60.5
	Mawal	42.5 to 186.6	3.4	9.1
Sholapur ...	(The whole district)	22 to 26	39.5	69.5
East Khand- eah.	(The whole district)	23 to 31	18.0	51.3
Belgaum	Belgaum	51.9 (Belgaum)	7.4	17.2
	Khanapur	71.1 (Khanapur)	2.3	4.0
	Athni	23.0	29.8	56.6
	Parasgad	23.2 (Saundatti)	30.6	53.3
Ratnagiri ...	(The whole district)	80 to 165	Nil.	Nil.
Kolaba ...	(The whole district)	88 to 135	Nil.	Nil.

There are, of course, many other factors which determine the proportion of land put under *jowar*, but it must never be forgotten that it is not usually suitable, even as a fodder crop, during a period of high rainfall.

As regards temperature, there are fodder varieties which will stand the hottest temperature of the hot weather in the Deccan or Gujarat, and provided the variety is well selected no degree of heat seems too great for their successful growth. They vary very much, however, in their resistance to heat, and those suited to each part of the year will be indicated in dealing with the varieties. All of them are injured by the least touch of frost.

*Jowar* is essentially a crop of semi-arid tropical and sub tropical regions, and is particularly valuable as a fodder crop in such areas,—as it is unaffected by the very dry atmospheric conditions which usually prevail, and it needs a minimum amount of soil moisture. This is illustrated by the fact that it requires less water per pound of dry matter produced than almost any other cereal crop which has been tested. The latest comparative tests of this with other

\* Statistical Atlas of the Bombay Presidency, 1906.

cereal crops are those of Briggs and Shantz\* in Colorado in 1910-11. They found that one pound of dry matter of each of the following crops required for growth the amount of water specified:—

Wheat	...507 lbs.
Oats	...604 "
Barley	...513 "
Maize	...869 "
<i>Jowar (Sorghum)</i>	...306 "

† Leather at Pusa found that *jowar* required a little more water than maize under his conditions, and his figures are—

Wheat	...554 lbs.
Oats	...469 "
Barley	...468 "
Maize	...337 "
<i>Jowar</i>	...437 "

Both these authors agree that *jowar* and maize need less water than any other cereal crop.

#### *Varieties of jowar.*

But in regard to their demands in the matter of temperature and water, the varieties of *jowar* suitable for fodder production differ considerably, and it will be well now to consider the varieties which are available in Western India, their characters and the conditions under which each of them is of peculiar advantage. In attempting to classify our varieties, I am leaving out of consideration and dealing in another place with those which like "Sudan grass" belong to the class of grass sorghums. None of these have as yet become, though they probably will become, of importance in Western India.

Apart from these we may classify the available *jowars*, which are suitable for being specially grown for fodder, according to whether (1) the stems are thick or thin, (2) the panicle (when they are allowed to flower) is lax or compact, (3) the glumes are light or dark in colour. The following table shows a classification on this basis.

#### I. The stem is thin.

##### (1) The panicle is lax.

(a) The glumes are red or black, and remain attached to the grain in threshing.

(aa) *Amber*—The glumes are red.

(bb) *Imp'hi*—The glumes are black and the head, on the plant, is drooping.

\* Bulletin No. 284, United States Department of Agriculture, Bureau of Plant Industry.

† Memoirs' Department of Agriculture, India (Chemical Series), Vol. I, Nos. 8 and 10 (1910-11).

(cc) *Collier*.—The glumes are black and the head, on the plant, is upright.

(b) The glumes are white, and fall away from the grain in threshing—*Sundhia*.

(2) The panicle is compact.

(a) The glumes are white—*Dudhia*.

II. The stem is thick.

(1) The panicle is lax.

(a) The glumes are white, lightly attached, and the grain small.

*Utavli and Khondi*.

(b) The glumes are white, lightly attached and the grain large.

*Shalu (Mal-dandi)*.

(2) The panicle is compact,

(a) The glumes are white, and lightly attached.

(aa) *Nilwa and Hundi*—The grains are small.

(bb) *Shalu (Dagdi)*—The grains are large.

(b) The glumes are black, lightly attached.

*Kalbondi (grains large)*.

Practically all the *jowars* which are particularly suitable for fodder, that is to say, such varieties as produce thin stalks and numerous side leaves, have generally either small heads of grain or the heads of grain have the form of a graceful much branched panicle. The best grain varieties, on the other hand, have thick woody stalks which support large heads of grain with usually a curved peduncle so that the grain head droops as the grain ripens.\*

We will discuss the character of each of the varieties above named.

#### SUNDHIA JOWAR.

*Sundhia jowar* is probably the best of the fodder varieties under the conditions when it is specially suitable. The chief advantages † are that it yields very heavily, that the stalks are thin and leafy, that under suitable conditions it matures quickly in about sixty days, and is therefore very

\* Mollison—Poona Farm Report, 1893-94.

† Quoted from Leaflet No. 6 of 1909 of the Bombay Agricultural Department.

valuable when famine is threatened, that there is less wastage in feeding than with almost any other *jowar* fodder, that it is highly nutritious and very much liked by animals, and that it will grow if sown in August after failure of *bajri* or *kodra* or other early sown monsoon crops.

There are two varieties of *sundhia jowar* well recognised and distinguished in its home in Northern Gujarat. These are known as *farfaria* and *amaria*. The former has a looser grain head than the latter, and the grain head of the latter droops somewhat. There is very little difference in their agricultural value and I shall not refer to them separately again.

The original home of *sundhia jowar* is in Northern Gujarat "where it grows to perfection on the deep, alluvial, sandy or sandy loam soils, either as a rain crop or under irrigation in the hot weather. In other parts of the Bombay Presidency, as a *kharif* crop it appears to thrive on almost any description of fairly good soil, with a moderate well distributed rainfall. It grows excellently on medium black soil but in the Deccan only does moderately as an irrigated crop either in the cold or hot seasons.\*" In the south of the Bombay Presidency it can probably be replaced advantageously by one of the other fodder *jowars*.

*Experience in Northern Gujarat.*—So far as Northern Gujarat is concerned Mollison† well describes the special value of *sundhia jowar* as follows:—"It grows with great rapidity and in the famine year 1899—1900 in most fertile parts of the fair province of Gujarat it was the means of saving the greater proportion of the work cattle which have been saved. The district abounds with old wells which are deep and hold an unfailing supply of water, and the cultivators, helped by *takavi* advances from Government, set themselves early in the season to dig *katcha* wells in very large numbers. The cost of digging such in the soft alluvial soil was trifling. These *katcha* wells gave a full supply of water throughout the season, and under numerous wells three crops in succession were grown between September 1899 and June 1900,—*Sundhia* first, then wheat in the cold season and again *sundhia* and *cheno* (*Panicum miliaceum*) in the hot weather. The whole manure supply of the year was available for these irrigated patches, and the crops of *sundhia* were almost without exception magnificent. These patches of green were indeed an attractive sight in a district which was cruelly stricken and where every tree was stripped of foliage and small branches to feed the starving cattle."

*Sundhia* played a similar part in the famine in Northern Gujarat in 1911-12, when it was again the favourite fodder in the district. On the Nadiad farm, on land usually well manured with farm-yard manure each year, the outturn ranged from 4,000 to 4,500 pounds of dry fodder per acre, the crop being irrigated six times.

I have no actual records of normal yield in the rains in these light soil districts of Northern Gujarat, but from experiments made at Nadiad it would seem that it may be profitably sown each year up to the end of

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\* Mollison—Text-book of Agriculture, Vol. III (1901), page 14.

† Poona Farm Report, 1900.

August, but not after that time. The actual yields of dry fodder obtained (1912) for sowings at various times are as follows\* :—

Date of sowing.	Irrigation.	Time between sowing and cutting.	Cost of crop per acre.	Yield of dry fodder per acre.
1912		Days.	Rs. a. p.	lbs.
August 5th	None	61.	11 8 0	5,040
September 1st	None	52	12 0 0	2,912
September 15th	Irrigated twice.	63	84 0 0	3,856
October 1st	Do.	58	42 0 0	3,008
October 15th	Irrigated three times	66	59 8 0	2,432

In any case it was ready to cut about two months after sowing.

These results were carried further in the following year, and the following figures were obtained† :—

Date of Sowing.	Irrigation.	Time between sowing and cutting.	Cost of crop per acre.	Yield of dry fodder per acre.
1913		Days.	Rs. a. p.	lbs.
August 22nd	None	55	27 12 0	6,760
September 15th	Irrigated five times	55	57 0 0	3,880
October 16th	Do.	64	51 0 0	4,400
November 15th	Do.	74	51 8 0	2,000
December 15th	F a i l e d.			
1914				
January 15th	Irrigated seven times.	84	66 4 0	2,000
February 15th	Irrigated eight times.	61	75 12 0	800
March 15th	Irrigated five times	57	55 0 0	6,600
April 15th	Do.	47	55 6 0	4,800

The average outturn† in the hot weather in Northern Gujarat is about 6,000 pounds of dry fodder per acre, and the maximum 12,000 pounds. The cost of production averages from Rs. 35 to Rs. 40 per acre.

\* Nadiad Farm Report, 1912-13.

† Letter from the Superintendent of Nadiad Farm.

*Experience in Southern Gujarat.*—In Southern Gujarat the soil on the whole is much heavier than in the districts to the north of Baroda. The northern districts have, in fact, on the whole a light *goradu* or alluvial soil: the southern have a black soil, and this as well as a fact that the rainfall is usually higher and more certain rather modifies the position of fodder *jowars* altogether and of *sundhia* in particular. It is, in fact, not actually grown to any extent, nor, in fact, any fodder crop, except since 1911 when lucerne cultivation has begun to spread.

Experiments have, however, been carried out on the Surat experimental farm since 1911 with *sundhia* on deep black cotton soil as a rains crop. The average cost of producing the crop, cut at flowering, was Rs. 15-8-0 and the yield per acre was as follows:—

Year.	Yield of dry fodder.
1911	... 2,875 lbs.
1912	... 2,824 „
1913	... 3,225 „

The yield on this class of soil is obviously less than on the *goradu* soils of Northern Gujarat, but with this yield, and grown as a rains crop, is ought to pay well and yield a profit of Rs. 50 per acre on the actual cost of production. It should be grown at the first fall of the rains or late in the season, that is to say, towards the end of August. When sown early it will be ready for cutting during the rains, and it is advisable to feed it green at this time and allow the roots to produce a second crop.\*

*Experience in the Deccan.*—Most of the experience with *sundhia* fodder has been obtained in the Deccan, where it was introduced in the early nineties by Mollison, and grown on a medium black soil with fair drainage. The yields obtained at the Poona farm in the years since 1893 are summarised below. I have re-calculated all the yields given to a basis of dry fodder, counting one pound of dry fodder as produced by 2½ pounds of green fodder. The first series concerns the production of fodder as a rains crop without irrigation. The crop was usually sown about the last week of June or the beginning of July, and reaped from the beginning to the middle of September when in flower.

Year.	Yield of dry fodder.	Cost of production.			Value of crop on sale.			Remarks.
		Rs.	A.	P.	Rs.	A.	P.	
1893	8,820 pounds.	44	0	0	75	0	0	After lucerne which failed.
1894	11,896 do.	16	0	0	107	0	0	
1895	8,960 do.	16	0	0	69	0	0	
1896	11,700 do.	24	0	0	91	0	0	
1901	8,846 do.	20	0	0	30	0	0	
1902	4,910 do.	46	0	0	38	0	0	Spoilt by continuous rain in July. Spoilt by heavy rain in September.
1903	6,053 do.	29	0	0	45	0	0	
1905	6,960 do.	35	0	0	52	0	0	
1910	8,436 do.	45	0	0				
1911	13,464 do.	43	0	0				

\* Surat Experimental Farm Report, 1913-14.



These figures, which it must be remembered are obtained on a farm to which a dairy is attached and hence which has a large quantity of manure available, show the characteristics of the crop. The amount of the produce has been very variable. Of course this may be in part due to the fact that the farm has been too much used for growing fodder, but the fact remains. The yield has varied from 13,464 pounds to only 3,846 pounds. In the case of the two lowest yields the reason for the failure can be assigned, but untimely rain is a thing which commonly occurs in the Deccan and must be taken account of. However, a very paying yield has been obtained in eight out of the ten years reported here, and in these eight years the yield was, on an average, 9,434 pounds or nearly 4½ tons of dry fodder per acre. Dry *sundhia* fodder in Poona has been valued at in some years about 130 pounds per rupee, but of course the money value varies much from year to year. Under the conditions of the Deccan, on moderate black soil, as a rains crop, Mollison\* summed up the position thus:—" *sundhia*, although it yields a finer description of fodder than any other variety tested, suffers in the Deccan from drought and from unfavourable climatic conditions to a greater extent than *nilwa* or the American sorghums do." Beyond this, *sundhia* requires, in the Deccan black soil, good land in good condition. In the absence of these conditions it is not a suitable crop for rains growing.

In one of the years (1904) for which records exist, the rains failed in July, and the *sundhia jowar* which was already above the ground was irrigated, with excellent results. This carried the crop over the drought and it gave a yield of 6,672 pounds of dry fodder at the usual time,—not nearly so much however as several of the other fodder *jowar* or maize grown beside it.

At other times of the year in the Deccan, as an irrigated crop *sundhia jowar* only does moderately, and is distinctly inferior to some of the other varieties to be afterwards described. As an example of its yield in the hot weather in Poona the following may be taken. The seed was planted in March and the crop taken during May. The yield was only 4,411 pounds of dry fodder per acre, costing Rs. 30 per acre to produce and only worth Rs. 34.

So far the data I have given are from crops grown at Poona. These can be supplemented by figures of crops obtained elsewhere in the Deccan. At Manjri, for instance, about eight miles from Poona in the Mutha valley, on good fairly deep black soil following sugar cane, during the rainy season without any irrigation, *sundhia* gave a yield of green material equal to 8,512 pounds of dry fodder†.

Again, experiments have been carried out in Khandesh at Dhulia since 1900 and some very interesting experience has been obtained. In 1910, when grown in July and August as an ordinary rains fodder, it yielded in two months the equivalent of 8,432 pounds of dry fodder, but was not equal in yield to a number of other varieties, as for instance *nilwa*, but on the other hand, it grew more rapidly. In 1911 the rains failed in Khandesh and experiments were made on *sundhia* as an emergency fodder, sown in July, August and September. The results were as follows:—

Date of sowing.	Irrigation.	Length of time from sowing.	Total yield of dry fodder.
1911 July 22nd	Irrigated eight times.	3 cuttings, 43, 89, and 153 days.	lbs. 12,756
August 22nd	Do.	2 cuttings, 50 and 122 days.	7,788
September 9th	Irrigated seven times.	2 cuttings, 62 and 146 days.	9,032

\* Poona Farm Report, 1896.

† Report for 1904 of Manjri Farm.

In general, in the Deccan one may say that while *sundhia jowar* gives a better class of fodder than any other variety, it is less hardy than some of the others, and it is only really the most suitable under normal conditions (a) for growing in the rainy season, (b) for growing on good well manured, well tilled, and well drained land, and (c) for growing when the rainfall conditions are pretty certain to prove favourable. In fact, it is affected by drought by the land being badly prepared and manured, and by other unfavourable circumstances more than other *jowars* and is not particularly suitable either as a cold weather or a hot weather crop.

*Experience in the Southern Maratha Country.*—The experience with *sundhia jowar* in the Southern Maratha Country or roughly speaking the Bombay Presidency south of latitude 17° N. has been smaller than in the Deccan, and is not so favourable to it. All the imported fodder *jowars* grown at Dharwar are considered as inferior to the variety locally grown for seed, but capable of being used as a fodder crop. The yield obtained when grown as a rains crop, cut from nine to twelve weeks after sowing, was as follows\* :—

	Yield per acre of green fodder.
1909-10	... 7,000 lbs.
1912-13	... 8,224 do.
1913-14	... 7,680 do.

These crops are very small, being equal, on the average to only 3,390 pounds of dry fodder, although grown on good land at the Dharwar experimental farm.

The position regarding *sundhia jowars* in the Dharwar district is well expressed in the following note†. It is written as applying to *sundhia nihwa* and *utavli jowars*, but applies to *sundhia* much more than to the others.

“These *jowars* come early to maturity after a growing period of nine to twelve weeks, and it is therefore important that in addition to favourable rain there should be ample sunshine during this period. At Dharwar it usually happens that for the greater part of the months of July and August the sky remains overcast, and drizzling showers fall at frequent intervals ..... Stem borers caused a lot of injury and the crops remained stunted and yielded poorly ..... These *jowars* were ready for harvest from mid-September to the first week in October, which proved rather inconvenient as the monsoon was not over and the *kadbi* could not be dried conveniently.”

So far as present information goes, therefore, *sundhia jowar* is not the most suitable fodder crop in the more generally moist conditions in the south of the Bombay Presidency.

#### DUDHIA JOWAR.

From the same part of Gujarat as *sundia* comes the very similar variety *dudhia*. Its head is small and dense, but in other respects it has much the same habit of growth as the *sundhia* varieties except that the stalks are somewhat coarser. It is usually grown mixed with *sundhia* in the Kaira

\* Figures supplied by Mr. T. Gilbert, Deputy Director of Agriculture, Dharwar.

† Dharwar Experimental Farm Report, 1910-11.

and Broach districts of Gujarat.\* In experiments made in Poona in 1896 and 1897, it was found to stand next to *sundhia* as a fodder crop there for the rains, and there was little to choose between the two.\* It has, however, been overshadowed by *sundhia* over which it has no special advantage, and I am not aware of any further experiments with it since that time. Its seed can only be obtained now in its own districts in Gujarat.

#### NILWA JOWAR.

While *sundhia* and *dudhia jowar* originate from Gujarat, *nilwa* appears to be essentially a Deccan variety. In the Deccan, in fact, it is not only grown for fodder but also for grain near "populous centres where fodder of fine quality is specially valuable. It has a small, moderately dense head of grain, with dull coloured rather inferior seed.....*Nilwa* has more leaf-growth than *sundhia*, with rather thicker stalks, but does not mature so quickly. The stalks in a dense crop are in no wise coarse, and there is no waste in feeding the fodder. If *nilwa* is cut green and a fair-stubble is left, a second or third cut in the same season may be obtained if rain is favourable or irrigation is given. This is a valuable characteristic, common to some varieties of *jowars* only."†

*Experience in the Deccan.*—Inasmuch as Gujarat is already supplied with very excellent fodder *jowars* in *sundhia* and *dudhia* practically all our experience with other varieties has been obtained in the Deccan and Southern Maratha Country, so far as the Bombay Presidency is concerned, and in the Deccan at any rate *nilwa* has proved of great advantage.

At the Poona farm, where there has always been fairly high cultivation and manuring, *nilwa* has generally given a larger yield of fodder than *sundhia* and the outturn in the several years since 1893 is interesting.

Year.	Yield of dry fodder.	Cost of production.	Value of crop on sale.	Remarks.
	lbs.	Rs.	Rs.	
1893	7,904	45	71	Following peas which failed.
1894	14,464	17	108	
1895	18,200	18	114	
1896	16,330	22	109	
1901	4,846	21	32	Stunted owing to continuous rain in July.
1902	6,946	46	46	Spoilt by heavy rain in September.
1903	16,048	42	72	
1904	10,144	21	76	
1905	10,068	23	75	

\* Poona Farm Report, 1897.

† Mollison.

These figures show that the yield has been variable, but has on the whole been higher than that of *sundhia jowar*. The crop was poor, as with *sundhia* in two years when unfavourable climatic conditions prevailed, but in each year the crop was considerably greater than with that variety. In other seasons the average yield was 13,308 pounds or slightly less than six tons of dry fodder per acre.

Thus *nilwa* is decidedly better in yield than *sundhia*, but on the other hand the fodder is not quite so valuable. When dry *sundhia* fodder was valued at 130 pounds per rupee, dry *nilwa* fodder was worth 160 pounds per rupee; when *sundhia* green fodder was selling at 250 pounds per rupee, *nilwa* green fodder was worth 300 pounds per rupee. *Nilwa* is thus about eighty per cent. as valuable as *sundhia* fodder.

On light land at Poona,—where light land usually means porous shallow soil,—during the rains without irrigation, *sundhia* is better than *nilwa*. Both of these do better during heavy rain and flooding than the other varieties, especially when this is followed by drought.\*

The figures just given apply to the plants cultivated as a rains crop without irrigation. *Nilwa* like *sundhia* is not very suitable as an irrigated crop in the hot weather, but for this purpose it is distinctly better than *sundhia*, though it requires more water. In 1895 the following results were obtained in the hot weather at Poona :—†

		Yield of dry fodder.	Cost	Value of produce.
		lbs.	Rs.	Rs.
<i>Nilwa</i>	...	6,369	36	42
<i>Sundhia</i>	...	4,411	30	34

*Nilwa* has not been found at all suitable for planting from August to January‡ in Poona.

This crop has now been widely grown at other centres in the Deccan and has proved its value as a rains crop. Thus for instance after sugarcane at §Manjri two types of *nilwa jowar* seed gave the following yields, which are very satisfactory :—

	Yield of dry fodder.	Cost.	Value of produce.
	lbs.	Rs.	Rs.
I	8,512	11	53
II	11,632	11	65

\* Mollison—Poona Farm Report, 1897.

† Poona Farm Report, 1895.

‡ Poona Agricultural College Farm Report, 1912-13.

§ Manjri Farm Report, 1904.

In comparing *nilwa* with *sundhia* it is always well to remember that *sundhia* matures considerably more quickly. In some places, in the rains, as at Dhulia, the difference has been found to be nearly a month, and hence in a year of scarcity of fodder *sundhia* would command a high price as being the only source of suitable fodder before the other varieties become ready.

*Experience in the Southern Maratha Country.*—The success which has attended this variety has led to experiment with it in the Southern Maratha Country, and while in certain places it has been very successful indeed, this success is by no means universal. At the military dairy farm, Belgaum, on black cotton soil, it has been found the best monsoon variety, and with abundance of manure gave an excellent outturn and an early harvest. In 1913, sown just as the rains broke on June 1st, a six-acre plot gave on August 25th an average of over 35,000 pounds of green material equal to 15,500 pounds of dry fodder per acre. The manager of this farm considered that for Belgaum it was the best monsoon variety.\*

At Belgaum, in the hot weather, while it grew fairly well on black cotton soil, it did not maintain its superiority. It showed great hardiness, however, as the following experience indicates. A plot was sown on March 14th, and was irrigated every nine days until the rains broke, when the crop of green fodder was cut and gave 20,000 pounds of green fodder. Immediately after cutting the river rose and flooded the whole plot, and yet a second crop was afterwards obtained without resowing equal to 10,000 pounds of green fodder or a total of 30,000 pounds of green, equal to over 13,000 pounds of dry fodder.† It is one of the characteristics of *nilwa* that two or more cuttings can be obtained from it provided manure and water are available in plenty.

At Dharwar experience has not been nearly so favourable, and while it yields better than *sundhia* as a rains crop, it is not considered to be comparable in value with the local varieties usually grown for grain, but capable of being used as fodder crops. In 1909-10, as a rains crop, it only gave 10,140 pounds of green fodder per acre, as against 22,000 pounds from the local variety.† There seems at present no reason for the introduction of *nilwa* into the conditions of the Dharwar district,

On the whole, therefore, we may describe *nilwa* as a fodder *jowar* particularly suitable as a rains crop in the black soil districts of the Deccan and the northern part of the Bombay Karnatak. It is hardier than *sundhia*, will give bigger yields on heavier soil and will better resist drought. On the other hand it matures more slowly than *sundhia* and the fodder is at least twenty per cent. less valuable in popular opinion. It is not the best *jowar* for hot weather growing, and is not suitable for planting at least after August.

#### UTAVLI JOWAR.

Another variety of fodder *jowar* which under the conditions of the Bombay Deccan has many advantages is *utavli*. Mollison describes it as growing more quickly than *nilwa* and particularly suitable for sowing midway between the *kharif* and *rabi* seasons. It has steadily grown in favour since it was introduced and is now among those most largely grown.

As already indicated it is a thick stemmed variety with head in the form of a lax panicle, and it gives decidedly small grain.

\* Mr. J. D. Lawton in letter to the author, dated August 13, 1914.

† Dharwar Farm Report, 1909-10.

Experience with this variety has been almost wholly in the Deccan, and the actual records I have been able to get have been almost entirely from Poona. In 1900, when grown as a rains crop on medium black soil, and when nearly all the *jowars* were spoilt by continuous rain in July, it gave the best yield of all. Compared with *sundhia* and *nilwa* the following yield was obtained:—

	Yield of dry fodder.
	lbs.
<i>Utavli</i>	... 7,575
<i>Nilwa</i>	... 4,846
<i>Sundhia</i>	... 3,846

In the years from 1902 to 1911, as a rains crop on well-manured land, it has given the following results:—

Year.	Yield of dry fodder.	Cost.	Value of produce.
	lbs.	Rs. s. p.	Rs. s. p.
1902	10,623	46 0 0	76 0 0
1903	14,213	40 0 0	70 0 0
1904	9,860	20 0 0	74 0 0
1905	6,424	15 0 0	
1906	5,970	11 0 0	
1910	9,800	29 0 0	
1911	13,700	36 0 0	

We have thus an average yield of 10,084 pounds of dry fodder per crop in the rains in a series of average seasons. At Manjri after sugarcane it gave a yield of 10,780 pounds of dry fodder in 1904. This makes it equal to *sundhia* in yield as a rains crop, and considerably below *nilwa*. But it must be remembered that it produces fodder 20 per cent. inferior to *sundhia* and only equal to *nilwa*. On the other hand it matures more quickly than *nilwa*, and this is a considerable advantage.

The difference in the length of time required for growth is well shown in an experiment made at Poona in 1905 as follows:—

Crop.	Date of sowing.	Date of flowering.	Number of days from sowing to flowering.
<i>Sundhia</i>	July 5th	September 5th	62
<i>Nilwa</i>	July 9th	September 19th	72
<i>Utavli</i>	July 10th	September 13th	65

Thus in length of time required to reach the flowering stage, *sundhia* is the shortest, *utavli* the next, while *nilwa* takes considerably longer.

But, as already indicated, the special value of *utavli*, is not as a rains crop, but as one to be sown later in the season in the Deccan, at least up to the end of August. At this time a rapidly growing heavy yielding fodder jowar is of great value. The following are some yields obtained in Poona on good well-manured land following other fodder crops in the hot weather.—

1909-10.

Following maize (April to June) *utavli* was planted in August and yielded in October 36,800 pounds of green, equal to 16,360 pounds of dry fodder at a cost of Rs. 60.

1910-11.

Following maize (February to May) *utavli* was planted in August and yielded in November 18,026 pounds of half dried fodder at a cost of Rs. 95.

In the Southern Maratha Country at Dharwar, as a rains crop, it yielded better than *sundhia* or *nilwa*, grew quicker than the latter, and reached a height of over six feet. The green crop obtained was 18,048 pounds of green fodder (equal to 8,000 pounds of dry fodder) per acre, but this was considerably inferior to the yield of fodder given by the local jowar "*Fulgar yellow*" when grown for this purpose.\* A quick growing rains fodder does not seem to be specially needed at Dharwar, where the rains continue longer than in the Deccan.

#### HUNDI AND KALBONDI JOWARS.

These two varieties, both suited particularly for growing as irrigated crops on the Deccan, differ in appearance when ripe in that the former has white glumes and small grains, and the latter has black glumes with large grains. They behave very similarly on cultivation, however, and as Mollison remarks, there is little to choose between them. They are both much coarser than those already described.

*Hundi jowar* was discovered under cultivation in the Sholapur district, and *kalbondi* in the Ahmednagar district. The former was first experimented with in 1896, and when sown in Poona in the hot weather gave in that year 10,791 pounds of green, equal to 4,796 pounds of dry fodder per acre in June. † It was said to be equally suitable in the cold weather.

These varieties have been continuously under experiment since that time. In 1898, grown as hot weather crops, they yielded as follows:—

Variety.	Date of sowing.	Date of cutting.	Yield of green fodder per acre.
<i>Hundi</i>	March 28th	1st crop—May 23rd to June 20th	13,702 lbs.
		2nd crop—July 14th to August 14th	10,741
<i>Kalbondi</i>	April 10th	1st crop—July 1st to July 13th	13,463
		2nd crop—No record.	No record.

\* Dharwar Farm Report, 1909-10.

† Poona Farm Report, 1896.

Taking the two crops of the *hundi jowar* together, this crop is about equal to 10,800 pounds of dry fodder.

In the years succeeding 1904 *hundi* has given the following results at the Kirkee Dairy Farm usually in two cuttings, as a hot weather *jowar* :—

Year.	Yield of dry fodder per acre.	Date of sowing.	Date of cutting.	Cost per acre.
	lbs.			Ra. a. p.
1908	( <i>Hundi</i> ) 8,400	March 28th	May 23rd and July 14th	no record.
1904	„ 12,460	April 20th	July 10th	81 0 0
1905	„ 5,320	March 1st	July 10th	55 0 0
1910	„ 19,300	March	July	144 0 0
1912	„ 8,772	April	June	23 0 0

Thus in five years, we have, for *hundi jowar* grown in the hot weather in Poona, an average yield of 10,850 pounds of dry fodder. Of course to secure this costs a good deal, as on the moderate black soil on which it is grown it needs irrigation about every eight to ten days.

It is usually stated that both *hundi* and *kalbondi* are good fodder crops for the cold weather, but we have no recorded experience of them at Poona. *Kalbondi* is, however, commonly grown as a cold weather fodder crop at Sangamner in the Ahmednagar district.\*

They seem, at either season for which they are suitable, to grow best on medium black soil of fair depth, with porous subsoil (*murum*) two to three feet below the surface.

#### SHALU JOWAR.

The various types of *shalu jowar*, of which there are many, form the typical *jowars* of the *rabi* season, that is to say of the season from August onward each year. There are many of them suitable for grain production and these are cultivated on an enormous scale: a few also are known suited to fodder growing. The varieties differ a good deal in appearance. One of them (*maldandi*) has a lax panicle, white glumes, and large grain: another (*dagdi*) has a compact panicle, with similarly white glumes and large grains. They are either grown entirely on the rain or on the rain supplemented by as much irrigation as may be necessary when grown as a fodder crop. The stalks are usually sweet but on the whole rather coarse when compared with the fine fodder varieties. The fodder is, however, greedily eaten by stock in both the green and the dry condition.

The outturn per acre does not compare with the heavy yields obtainable from the varieties cultivated in the rains or even in the hot weather. As an example of the yields obtained on well tilled and manured land, with such

\* Information supplied by Mr. G. K. Ranade, L. Ag.



irrigation as is necessary given to keep the crop growing vigorously, in 1903 on the Poona Farm a crop gave a yield of 9,553 pounds of green, equal to 4,250 pounds of dry fodder per acre at a cost of Rs. 34.\* Again in 1904, under similar conditions, sown on September 20th, and cut on December 17th, it gave 2,430 pounds of dry fodder per acre at a cost of Rs. 11.

Other records at Poona of the growing of *shalu jowar* for fodder are as follows † :—

Year.	Yield of dry fodder per acre.	Date of sowing.	Date of cutting.	Cost per acre.
	lbs.			Rs. a p.
1906	1,104	October 23rd	February 6th, 1907	16 0 0
1910	3,884	October	January 1911	17 0 0
1911	5,540	November	February 1912	66 0 0

In very considerable measure the yield depends on the amount spent in irrigation,—but in any case it is considerably less than that obtained with other *jowars* at other times of the year.

There is little more to say with regard to *shalu* as a special fodder crop: it is usually allowed to ripen and produce seed, the straw (*kadbi*) forming an excellent dry fodder. But in a dry or famine year, *shalu jowar* cultivated for fodder only, which grows quite well during the rabi season and the cold weather, is one of the emergency fodders which would be of great value,—and could be planted much later than would be necessary if it were used for the production of grain.

#### AMERICAN SORGHUMS.

Two American sorghums were introduced by the Bombay Agricultural Department about twenty years ago. They belong to the class originally cultivated for sugar, but which have been diverted from their original purpose, both in America and here, to that of producing fodder. The two varieties which have come into general use here are '*Amber*', and '*Collier*', which are similar in most respects but the former has yellowish brown glumes, and the latter blackish glumes. *Collier*, again, ripens rather the earlier of the two, but if anything *Amber* is the more vigorous with us. In growing the plants for seed they have the advantage, like *sundhia*, that the drooping panicle affords no foot hold for birds. Both varieties are leafy, and the leaves keep green even when the seed ripens.

Mollison ‡ summed up the position regarding these American sorghums as fodder crops as follows:—"In a favourable season, on good, fairly deep, free working soil, well stocked with manure, the (American) sorghums will yield as heavily as the best indigenous varieties: but with deficient rainfall,

\* Poona Farm Report, 1904.

† Dairy Farm Report, 1905.

‡ Textbook of Agriculture, Vol. III.

or other unfavourable conditions, or on light poor soil, or as irrigated crops, they do not in the Deccan succeed so well as *nilwa* or *utavli*. The stalks are comparatively thin, free from crude fibre, the side leaves numerous and well developed, and the stalks when nearly ripe contain about ten per cent. of sugar.

Some of the records of these varieties as rains crop on medium black soil in Poona are as follows :—

Year.		Yield of dry fodder per acre.	Value of crop per acre.	
		lbs.	Rs. s. p.	
1894		12,457	56 0 0	
1895		15,385	103 0 0	
1901	( <i>Amber</i> )	6,859	46 0 0	} Spoilt by heavy rain in September.
	( <i>Collier</i> )	6,918	46 0 0	
1902	( <i>Amber</i> )	12,529	52 0 0	(Very dry July). (Do. do.)
	( <i>Collier</i> )	19,903	84 0 0	
1903	( <i>Amber</i> )	11,025	83 0 0	
	( <i>Collier</i> )	11,800	89 0 0	
1904	( <i>Collier</i> )	9,910		
1909		8,080	36 0 0	

Thus on the average of 10 crops, these American sorghums have given a yield of 11,500 pounds of dry fodder or a little over five tons per acre,—coming thus considerably above *sundhia* but not as high as *nilwa*. *Collier* has in these experiments yielded a little better than *Amber*.

On light land, which, as already stated, usually means in the Deccan a shallow soil with very porous subsoil, and in a normal season, they yield considerably better than *sundhia*, and not quite as well as *nilwa*. The following are figures obtained in 1894 :— \*

Crops.	Yield of dry fodder per acre.	Value of crop per acre.
	lbs.	Rs. s. p.
<i>Sundhia</i>	4,912	38 0 0
<i>Nilwa</i>	9,109	61 0 0
American sorghums (1)	8,360	55 0 0
(2)	7,175	48 0 0

As cold weather crops, the American sorghums are failures at Poona,\* and in the Deccan generally.

Apart from Poona definite experiments with these American sorghums have not been made to any extent, but they have nevertheless established themselves as useful rains fodder crop, giving an excellent quality of fodder,—second only to *sundhia*, in fact,—and producing also a high yield.\*

I have recently been informed that they have flourished well in the Konkan, with a rainfall of about one hundred inches, as a rains crop, when planted on *kurayat* or sloping hill side lands where the drainage is good.†

#### IMPHI JOWAR.

*Imphi* is an African sugar sorghum, nearly related to those just described from America, and yields nearly as satisfactorily as these latter. It has been grown ever since 1893 in Poona on medium black soil, as a rains crop and has yielded in some years as follows :—

Year.	Yield of dry fodder per acre.	Value of crop per acre.	Remarks.
	lbs.	Rs. s. p.	
1894	11,220	75 0 0	
1900	4,305	29 0 0	Spoilt by continuous rain in July.
1901	8,552	57 0 0	
1902	15,196	71 0 0	
1903	11,720	68 0 0	

Leaving out the case of 1900 where the crop was spoilt by heavy and continuous rain in July, the yield has been 11,672 pounds of dry fodder or 5·2 tons per acre per annum.

As a hot weather fodder crop it is inferior to *hundi* and *kalbondi* previously mentioned and about equal to *nilwa*‡ and it is unsuitable as a cold weather crop in the Deccan.

#### SOUTHERN MARATHA COUNTRY JOWARS.

Though not specially cultivated as fodder crops one or two of the *jowars* grown in the Southern Maratha Country merit special mention in this connection. They combine in some degree, the two valuable characteristics of having comparatively thin tall stalks and a fairly well developed head of grain, which are so rarely found together elsewhere. They have, in fact, proved themselves the best varieties to grow as fodder *jowars* as well as grain *jowars* in the Dharwar district, and are the nearest examples of a double purpose crop that we have. Perhaps the best of these is the so-called

\* In the Punjab, these American sugar sorghums have given 13 tons of green fodder per acre, under irrigation, equal to say 5½ to 6 tons of dry fodder, see Annatt, Pusa Bulletin, No. 41 (1914).

† Private communication from Rao Sahab G. K. Kelkar.

‡ See Poona Farm Reports, 1894 and 1895.

'Fulgar yellow,' grown near Dharwar. This grows more slowly than any of those we have previously discussed. As a rains crop this does not matter in normal years at Dharwar and the relative yield in 1909 at Dharwar is as follows. All were sown on July 16th.

Crop.	Yield per acre in green fodder.
	lbs.
<i>Sundhia</i>	7,000
<i>Nilwa</i>	10,140
<i>Utavli</i>	18,048
<i>Fulgar yellow</i>	22,876

In general with regard to the varieties of fodder *jowar* we may state as follows with regard to the Bombay Presidency (excluding Sind).

(1) In Northern Gujarat on alluvial soil, *sundhia* is an ideal fodder crop for the rains and for the hot weather. It is not suitable for sowing after the end of August, when some type of *shaku* would probably be preferable.

(2) In Southern Gujarat, on black soil, there is little experience available, but *sundhia* does fairly well as a rains crop. The yield is, however, very much smaller than in the lighter soils and lighter rainfall of Northern Gujarat.

(3) In the Deccan, where most of our experience has been obtained on medium black soil, the following may be stated for the various *jowars*.

(a) *Sundhia* gives the best fodder and will, in Poona, as a rain crop, in ordinary seasons, give four tons or a little more of dry fodder per acre on good well tilled and well manured land. It is susceptible to drought or to excess of water. It usually flowers and is fit for cutting in sixty days or thereabouts. It is not suitable as a hot weather irrigated crop or as a cold weather crop, nor on light and poor land.

(b) *Nilwa* gives a fodder twenty per cent. less valuable than *sundhia*, but gives a larger yield. In ordinary seasons, in Poona as a rains crop it will give six tons of dry fodder on good well tilled and well manured land. It is less susceptible to drought or to excess of water and is the best variety on light poorer soil. It usually flowers and is fit for cutting in seventy to seventy-five days. It is not suited for planting after August and is not the best as a hot weather irrigated crop.

(c) The American sorghums *amber* and *collier* lie between the above two in point of yield, and will, in ordinary seasons at Poona, give five tons of dry fodder on an average on good well tilled and well manured land. With deficient rainfall, or on light poor soil they are not so good as *nilwa*. They give a fodder nearly as good as *sundhia*. They are not suitable as hot weather irrigated crops or as cold weather crops. They usually flower and are fit for cutting in about the same time as *nilwa*.

- (d) *Impbi* is almost similar in its characters to the American sorghums.
- (e) *Utavli* gives a fodder very similar to *nilwa* but it flowers and is ready for cutting after about sixty-five days. As a rains crop, in ordinary seasons at Poona, it will give five tons or a little less of dry fodder per acre, thus being a little better than *sundhia* in point of yield and consequently inferior to *nilwa*. The fodder is only equal to *nilwa* in value. Its peculiar value is that it yields heavily when planted in August, when irrigation has to be used. It is not suitable for hot weather irrigation.
- (f) *Hundi* and *kalbondi* give coarse fodder, and grow even more slowly than *nilwa* coming to flower in eighty days. They are not suitable for growing in the rains, but are the best for the hot weather under irrigation, yielding on the average about five tons of dry fodder per acre on good well tilled and well manured land.
- (g) *Shalu jowars*, of various kinds, are the only ones suitable for cold weather growing, after September, under irrigation. They yield, however, much less fodder than those previously indicated, not usually much more than two tons of dry fodder per acre on good well tilled and well cultivated land.

(4) In the Southern Maratha Country, the conclusions reached in the Deccan seem to apply in the larger part of the Belgaum district. In Dharwar, none of the *jowars* above mentioned can be recommended as a rule in comparison with the local *fulgar yellow* or similar crops in the rains. This grows more slowly than *sundhia* or even *nilwa*, but will give from four to five tons of dry fodder on good well tilled and well manured land.

(5) In the Konkan, few experiments have been made, but the American sorghums seem to grow and yield well on *kurayat* land in the rains.

#### Cultivation.

When grown for the production of grain, the *jowars* need only very thin seeding and are always better for being grown wide apart: the seed rate necessary is in fact only about eight to ten pounds of seed per acre. When on the other hand *jowar* of any sort is grown for fodder in good land, it should be sown very much more thickly. "None of the varieties examined have any decided tendency to produce more than one shoot from one root. Numerous shoots from one root indicate a check in the early stages of growth or a diseased condition. The result of this is that when it is desired to produce a large yield of leaf and stalk per acre, it is no use relying on tillering, but additional seed must actually be sown. If, however, it is sown thickly the stalks will grow tall and thin, and produce small heads of grain."\*

The best amount of seed to sow per acre for fodder has been a matter of experiment at Poona. The varieties differ naturally in the most effective amount owing partly to their different habit of growth, and partly to differences in the size of the grain. As examples of the results obtained I quote as follows:—

*Nilwa jowar* 1893 (Rains crop)—

Seed rate.	Yield of green fodder per acre.
31 lbs.	... 20,514 lbs.
52 "	... 22,004 "
80 "	... 29,531 "

\* Mollison (l. c.)

*Nilwa jowar* 1895 (Rains crop)—

Seed rate.	Yield of dry fodder per acre.
38 lbs.	... 9,888 lbs.
60 "	... 9,560 "
84 "	... 10,271 "

*Sundhia jowar* 1895 (Rains crop)—

Seed rate.	Yield of dry fodder per acre.
38 lbs.	... 7,114 lbs.
60 "	... 8,642 "
79 "	... 9,994 "

As a result of much experiment Mollison (*loc cit.*) lays down the best seed rate for each variety as follows:—

<i>Sundhia</i>	...50 to 60 lbs. per acre.
<i>Nilwa</i>	...40 to 45 "
<i>Utavli</i>	...40 to 45 "
American Sorghums and <i>Impbi</i>	...50 lbs. per acre.
<i>Hundi</i> and <i>kalbondi</i>	...40 "

*Shalu* should have the same rate as *hundi* and *kalbondi*.

*Soil for jowar fodder.*—*Jowar* fodder flourishes on almost all the soils of Western India unless, on the one hand it is undrained and remains wet, or on the other, it is too shallow and dry. A medium black soil, well drained below, suits it perfectly: a light soil, provided it is deep, as in the *gora-tu* soils in Northern Gujarat, suits it also. It will, as a rule, stand drought rather than waterlogging, but on the other hand a firm tenacious soil, provided it is well drained, is perhaps the ideal condition under which it grows. *Jowar* is one of the typical crops of the Deccan black soil area of India.

*Methods of Cultivation.*—The methods of cultivation which have been found most effective differ a little in the different classes of soil in Western India, and vary considerably according to the season in which they are grown.

In the case of the rains (*kharij*) crop, the land should be ready for sowing by about the middle of June. Preparatory tillage should, if practicable, begin in the hot weather before the monsoon rains commence, when the land should be ploughed shallow, and subsequently harrowed three or four times so that there will be a thin layer of loose soil on the top, and below this a firm seed bed. This latter is necessary with *jowars* and if it is not obtained, the crop will grow less vigorously and be, moreover, very liable to lodge.

The crop should be manured with about five tons per acre of well rotted cattle or farmyard manure, or with an equal quantity of poudrette when the latter is available. The manure should be spread before ploughing, and ploughed into the land.

Very large yields can be produced by the use of sewage or sewage effluent. On the Poona Experimental Farm in 1899-1900, the following outturns of various *jowar* fodders were obtained :—

<i>Sundhia</i>	...32,480 lbs. of green fodder per acre.		
<i>Nilwa</i>	...44,716	”	”
American sorghums ( <i>Amber</i> )	...55,132	”	”
American sorghums ( <i>Chilser</i> )	...54,740	”	”

The American sorghums seemed particularly to be suited to growing under sewage effluent.

At Ahmedabad and Karachi crude sewage is put on somewhat sandy land in large quantities, and magnificent fodder crops are raised. At the former place the land is rented at the rate of Rs. 140 per acre, and *sundhia* fodder is one of the favourite crops raised by the tenants for the Ahmedabad market\*.

The best method of sowing the seed is by a four coultered drill with nine inches between the rows, as soon as the soil is in a sufficiently moist conditions. It should be done in one direction only across the field to make interculture possible†. Such interculture is very valuable, and should be conducted for the first time when the seedlings have grown to a height of four to five inches and the second after an interval of about three weeks, the exact time depending on the vigour of the crop. These operations will form a good mulch, and also destroy weeds that spring up during the early part of the monsoon.

In the case of autumn (*rabi*) fodder *jowar*, which is usually either *shawa* or *utawi*, the land should be ploughed early in the monsoon, and thereafter frequently harrowed to destroy weeds, to prevent the formation of a crust and break it up if it is already formed, and to increase the absorption of rain water. Well rotted cattle or farmyard manure, or pondrette if available, should be given at the time of ploughing at the rate of from five to seven tons per acre.

Sowing should be done with a four coultered drill as with the *kharij* crop, and immediately after the seed is covered, beds should be made as a provision for irrigating the crop in future if necessary. The beds should be long and narrow—five feet wide. The length depends on the levels in the field, as the beds must be level for irrigation purposes. They should be, however, as long as possible, as the cost of keeping the crop free from weeds

\* See Kelkar—Night soil, a valuable manure. Bulletin No. 84 (1909), Bombay Agricultural Department.

† After a good deal of experience we have come to the conclusion that this method is preferable to that recommended by Mollison (Textbook of Agriculture, Vol. III, page 14). He recommends that the seed “should be broadcasted by hand in the furrow behind a plough, the soil having been previously worked to a fine friable condition. Even distribution of seed is also secured by using a four coultered seed drill, first lengthwise and then across the field. The coulters should be about twelve inches apart. Two seed drills should be used simultaneously—one lengthwise, the other across, because then the field is finished more quickly, and there is less risk of the cross sowing being interrupted by rain.”

is thus reduced by substituting the bullock hoe in place of hand labour. Moreover, the interval between two consecutive waterings may be lengthened by forming a good soil mulch with the bullock hoe, and so preventing surface evaporation. A well levelled field allowing for the formation of large irrigation beds or irrigation furrows across the fields is of great importance in the cultivation of *rabi* crops.

In the case of hot weather fodder *jowars*, usually *hundi* or *kabondi*, the land should be prepared as detailed in the case of *kharif* crops, and the soil should be made ready for sowing about the beginning of March. The manuring should be heavy in this case, about ten tons per acre of well rotted cattle or farm yard manure or of poudrette. Long and narrow beds for irrigation should be made as soon as the field is sown, and the remarks about levelling for the fields with *rabi* jowar are of equal or greater importance with fodder grown in the hot weather.

A hot weather crop needs regular irrigation, and irrigation is required every eight or ten days in the Deccan or every four or five days on the light soils of Northern Gujarat. The first watering should be given immediately after sowing, and the second and third after an interval of four days. The soil between the rows should be loosened by bullock hoeing two or three times before the crop is six weeks old.

The interculturing of fodder crops is necessary, but on account of the thick sowing it need not be so frequent or so long continued as with the crop grown for grain. Two or three intercultures are generally sufficient. The fodder soon shades the ground, and thereby makes further interculturing operations impracticable and unnecessary.

*Mixed Crops.*—It is a common custom, and one which has much to be said for it to grow the *jowars* for fodder as mixed crops with one or other of the pulses. This is one way of getting over the difficulty that the continuous growing of *jowar* on the same land tends rapidly to cause the crops to become unhealthy, the other method of meeting the difficulty being the adoption of a suitable rotation.

In growing a mixed crop, either in the rains or in the *rabi* season the pulses which have proved successful with the jowar are *kulthi* (*Dolichos biflorus*) on light soil in the rains, and *mug* or *utid* (*Phaseolus mungo*), *chavli* or cowpea (*Vigna catianga*) or *val* (*Dolichos lablab*) on heavier soil. They are either grown in separate rows, every fourth row being pulse seed, or simply sown as a mixture of seeds. The former method has been the usual practice with us.

Similar mixtures have been successful in America, but there the seeds have usually been sown mixed, though the mixture of seed is very difficult to drill\*. It is found that the best mixtures are sorghum and cowpeas, and sorghum and *Dolichos biflorus* (*kulthi*). The latter is found to be most drought resistant. The maximum yield of these two mixtures in dry fodder was as follows in Texas when sown in the proportion of seven parts of sorghum and one part of pulse seed:—

- (1) Sorghum and cowpeas ... 3,600 lbs. per acre.
- (2) Sorghum and *kulthi* ... 4,400 lbs. per acre.

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\* Texas Agricultural Experiment Station, Bulletin No. 132 (1910).



In Pennsylvania the average yield of a mixture of sorghum<sup>o</sup> and cow-peas was 4,512 pounds of crop for green soiling per acre. In reaping the mixture of sorghum and cowpeas, the shock of the reaper caused the loss of a large part of the leaves of the cowpeas and so a reduction in the fodder value.

On the whole, the growth of these mixed fodder crops has probably much future before it in Western India, as the resulting fodder is much more valuable than the jowar fodder alone.

*Rotations.*—As already stated, *jowars* cannot be grown continuously on the same land: they rapidly became unhealthy. This is partly met by growing mixed crops. Where the amount of land is limited and the demand for fodder continuous, it can equally well be met by growing *jowar* and leguminous crops as separate crops in the same year. The *jowars* are then grown in the rains, and a leguminous crop follows in the fair season. The leguminous crops which are best for this purpose are *val* and *chavli* on the one hand, and berseem or Egyptian clover on the other and the rotation can be continued for a number of years without the crops being unhealthy. Mustard has also formed a good rotation with fodder *jowar* in the Central Provinces.

If land is abundant, the *jowar* crop enters into the ordinary rotation of the farm, a practice which does not need separate treatment here.

#### *Jowar as a fodder crop in Sind.†*

The conditions which prevail in Sind are different from those obtaining in any other part of the Bombay Presidency in that the country is so dry that practically all cultivation at any time of the year has to depend on irrigation. In Lower Sind, owing largely to the lack of water facilities, fodder is very expensive: in Upper Sind on the other hand fodder, chiefly *jowar* straw (*kadbi*) and wheat straw, is cheaper than almost anywhere else in Western India. Apart from the immediate neighbourhood of towns, *jowar kadbi* can be usually bought for about four annas per one hundred pounds, and wheat straw a little dearer. This is, however, material produced as a side product in the growth of grain.

Little has been done, even in Upper Sind, in the growth of any special fodder crops, but the experience obtained on the Military Dairy farm near Ruk, and on the experimental farm near Sukkur shows that *jowar* grows excellently as a fodder crop, and if plenty of water is available, gives enormous returns.

The actual practice adopted at Ruk is as follows. Owing to the uncertainty as to the time when the inundation canals will run (for they have been known to be available for only four weeks in the year) the land is ploughed during the cold weather and early months of the year when quite dry, and held ready for seeding. When the water is expected, the seed is put into this dry ground, and the water, on arrival, is run on to it. Of course the preparation of land in this condition needs good ploughs and bullocks, and the single disc plough has been particularly useful. The Sabul plough of Messrs. Ransome, Sims, and Jefferies has been found to be most useful for cross ploughing. Where the land is shallow, as is often the case, the Egyptian plough is very suitable. It is found very inadvisable to turn up the sandy subsoil.

\* Pennsylvania Agricultural Experiment Station Report (1909).

† This is based on notes kindly sent to the author by Messrs. Frost and Reddick of the Military Dairy Farms Department.

The crop found to be most suitable is the *milwa* or as it is termed in Sind, the "Sind Red." Sixty pounds of seed per acre have been profitably used.

The crop is ready for cutting for fodder by the latter part of September. It has been cut in the milky stage of the seed, with the "Nerbudda" or "McCormick's No. 4" mower. Where labour is dear and population so small the use of cutting machines in any large scale growth of fodder is almost necessary, and the above two appear to have given better results than any others.

On good land, free from salt (*kalar*), the presence of which is perhaps the greatest difficulty in agriculture in Sind, enormous yields can be obtained. An outturn of 80,000 pounds per acre of green fodder may be expected on the best lands, and an average of 50,000 pounds per acre should be generally obtained. This average is at least equal to 20,000 pounds per acre of dry *jowar* fodder, or from nine to ten tons.

On the military dairy farm at Ruk (Sind) the greater part of the material is chaffed, and made into silage; the remainder is dried into *jowar* hay, and both have proved excellent fodders.

In applying this method, the most important points to be considered in getting a successful crop are—

- (1) the preparation of the land beforehand, ready to take immediate advantage of the water when first available.
- (2) the keeping of all the irrigation channels ready with sides well turfed, to prevent loss by percolation,
- (3) the bunding of the land into convenient plots, sloping very gently but regularly from the inlet to the end of the plot, so that there are no depressions and the water is evenly distributed.

#### *Poisonous character of young jowar plants.*

The use of *jowar* is affected by one great difficulty. The plant cannot be cut and used as fodder until the flowering stage owing to its being very poisonous to stock in its earlier stages. Whenever grown, therefore, it must be kept till it flowers before using it, as even when dried there seems a good deal of doubt as to whether it does not still contain some of the poisonous principles.

• These facts have been long known in India where the following points are usually stated by experienced cultivators.

- (1) The *jowar* fodder is usually dangerous till the flowering stage.
- (2) The dried fodder is much less dangerous than the green fodder even if it is dangerous at all.
- (3) The *rabi* varieties are much more dangerous than the rains varieties.
- (4) *Shalu* *jowars* generally are the worst.

(5) The most dangerous of all is a crop which has grown vigorously and luxuriantly and then been checked and stunted by drought or disease.

The poisonous effect of the fodder is very striking, and has been attributed to many causes. The following is a description of its effect from experience at Allahabad.

"There is some danger of poisoning the animals fed on any species of sorghum (*i. e.* *jowar*) which has been cut when only a few feet high after

a long break in the monsoon . . . . . Animals which have been fed on the poisonous plants die very soon with symptoms resembling tympanitis: in some cases animals have died within twenty minutes of eating the fodder. An instance occurred on the Allahabad farm when sheep which were hired for the purpose of stock manuring, were at the request of the owner turned out to graze an aftermath crop of *sorghum vulgare*. Eight of the sheep died within a few minutes, and many more were saved merely by the rapid administration of purgatives. During lengthy breaks in the monsoon, when the sorghum thus becomes poisonous . . . . . there is danger of grass cutters bringing in some of the small plants of the sorghum when chilling grass from among the crops. At Allahabad in the summer of 1896, a number of horses belonging to private individuals died from the same. The season was an exceptionally dry one; in fact, the monsoon failed, and the crops being stunted and partially withered, the grass cutters were allowed by the ryots to take grass from the jowar fields."<sup>\*</sup>

Similar results have been described in other countries. Peters in 1901 in Nebraska, U.S.A., describes how fifteen cattle broke into a field and remained twenty minutes; three became sick and died in a few hours. The same worker then put two young cattle in the field, one ate the jowar and was so badly affected that it fell ten minutes after entering the field, and lay with twitching muscles in various parts of the body, paralysis of the tongue and increased salivation. It had eaten one and a half pounds of sorghum leaves.<sup>†</sup>

The cause of this was for long unknown. It was attributed to various causes, including the presence of nitrate of potash in the plant\*. It was, however, shown by Dunstan and Henry<sup>‡</sup> in 1902 that the young plant when crushed in water gave hydrocyanic (prussic) acid, and evidently contained a substance (cyanogenetic glucoside) which was capable of producing the poison when in the digestive system of an animal. These observations have been confirmed in almost all the *jowar* (sorghum) growing parts of the world since that time. Some of the determinations of the hydrocyanic acid which the fodder is capable of giving are as follows.—

(1) Leather<sup>§</sup> (India) found that one pound of green fodder grown under irrigation, and in the flowering stage, gave 1.28 grains of hydrocyanic acid. The quantity in the various parts was very variable. In a sample giving 0.17 grains hydrocyanic acid per pound in the dry sample, the leaves gave 2.5 grains, the stalks 1.1 grains, and the flowers only 0.25 grains. He states that drying in the sun had no effect on the quantity of hydrocyanic acid.

(2) Brunnich<sup>¶</sup> (Queensland) found that the poison decreased as the crop matured, and it was safe when the seed developed. Drying does not remove it, and high manuring with nitrogenous manures causes it to increase. He considered that it was specially dangerous to feed the *jowar* fodder to fasting animals. The highest quantity he found was 0.81 grains per pound of green fodder. He thought that if there was less than 0.5 grains per pound of green fodder it was safe. Maxwell,<sup>||</sup> also in Queensland gave similar results, but considered that the quantity of poison varied much with the soil.

\* Meagher and Williams—The Farm Manual (Calcutta 1903), page 59.

† Nebraska Station Report, 1901.

‡ Proceedings of the Royal Society, Vol. LXX (1902).

§ Agricultural Journal of India, Vol. I (1900), page 220.

¶ Journal of the Chemical Society, Vol. LXXXIII (1903), page 788.

|| Queensland Agricultural Journal, Vol. XIII (1904), page 473.

(3) Trumbull (Nebraska, U. S. A.)<sup>\*</sup> found the following quantities of hydrocyanic acid produced by plants in different degrees of vigour. Dark green healthy plants 50 cm. long—0.1215 per cent.; yellowish green plants 35 cm. long—0.0499 per cent.; yellow plants only 22 cm. long—0.0405 per cent. His figures confirm the conclusion that vigorous plants contain more than poorly grown plants.

(4) Balfour† working in the Soudan, where the plant has caused much poisoning, gives a case which yielded, when 16 inches high, 0.035 per cent. of hydrocyanic acid. The opinion there is the same as in India, as given by Neville and by Borton (quoted by Balfour), that *jowar* is the most dangerous when (1) it has been stunted for want of water and has then grown vigorously when water is obtainable (Neville); (2) it is stunted by rainfall suddenly ceasing after a good start in growth has been made. In the Soudan, the people consider that ruminants (cows &c.) are much more easily affected than donkeys or horses.

(5) Willaman and West‡ (Minnesota, U. S. A.) are the most recent workers on the subject. They conclude as follows:

- (a) When sorghum (*i.e.*, *jowar*) is grown on poor infertile soil, added nitrogen (*i.e.*, nitrogenous manure) may slightly increase the amount of hydrocyanic acid in the plant. With a fertile soil and abundant nitrogen this effect may not be produced.
- (b) During the first three or four weeks of the plants' life the prussic acid is concentrated in the stalks. Then it rapidly decreases and disappears there, but apparently persists in the leaves in decreasing percentages until maturity.
- (c) Climate and variety may be more important factors than soil nitrogen in determining the amount of acid (*i.e.*, prussic acid) in the plant.

They found that weak and stunted plants contained little poison, but this does not of course touch the point held by the cultivators here, and in the Soudan also (*vide sup.*), that vigorous plants, afterwards stunted, are particularly dangerous.

The general result of all this discussion is then—

- (1) that the cause of the poisoning action is hydrocyanic acid produced when the fodder is eaten;
- (2) that *jowar* fodder should not be used till after flowering, either in the first or the second crop;
- (3) that regular growth should be aimed at, sudden growth after it has been stunted, or stunting after good growth tending to increase the poisonous properties;
- (4) that it remains very doubtful whether drying of poisonous fodder gets rid of the poison;
- (5) that the ratoon crop is much relished by cattle, but when young is more poisonous than the original crop §;

\* Nebraska Station Report, 1909.

† Report, Welcome Research Laboratory, Khartoum, 1903-04.

‡ Journal of Agricultural Research, 1915.

§ Benson and Subba Rao. Bulletin No. 55. Department of Agriculture, Madras page 119.

### Utilisation of Jowar Fodder.

*Reaping.*—The fodder jowar crop, when grown in the manner indicated, that is to say, with a high seed rate, and thick on the ground, has thin stems which, though usually in this country cut by the sickle, can quite well be cut by the ordinary mowing machine, and this latter is, of course, used where large quantities of fodder are to be utilised.

*Utilisation of jowar fodder.*—As with almost all fodders, there are three ways of utilising the crop, (1) by green soiling; (2) by making into hay; (3) by making into silage.

(1) Green soiling, or cutting the crop in the field as required and feeding green to stock, is the usual way of utilising the crop, and indeed the only method of employing the crop grown in the hot weather. If used in this manner it is of great importance that the material should be well chaffed before being given to the cattle, as otherwise, especially with the coarser varieties, there will be great wastage. Meagher and Williams\* consider that the pieces should not be more than one-third of an inch long.

(2) *Making into hay.*—The question of making hay from jowar fodder does not usually arise in connection with the crop grown during the hot weather, which is grown for immediate use. The crop grown during the rains is likewise not produced at such a time of the year as is favourable to the production of hay. Over nearly all the districts of Western India, the crop sown in June or July is ready for cutting while the weather is still extremely uncertain, and efforts in Poona to convert the plants into hay have not been very satisfactory. The crop, if made into hay, should be made perfectly dry,\* otherwise it will turn black in the stack and go mouldy.

From American experience, it may be stated that when made into hay it is often more difficult to keep than maize and most other kinds of fodder. However "when well cured and stored in a dry place, it may be kept in good condition for a year or more †" and often in America it constitutes the entire hay supply of many farmers. "Even in the great corn (*i.e.*, maize) belt, Noring states it is widely grown and fed to stock as a change and appetizer. All kinds of stock will eat sorghum fodder more readily than they will corn (*i.e.* *maize*) fodder, and there is much less waste in feeding." The following method of making hay has been recommended in Texas. ‡

"After mowing, allow the sorghum to lie upon the ground, sufficiently long to dry out at the ends of the blades. If the crop is thick, it should be turned over upon the ground to expose the bottom portion of the crop to the sun for a short time; usually one full day's sun is required to dry it sufficiently to be put into the cock. These hay cocks may be five feet high and four in diameter, of the shape of an old-fashioned beehive. All of the hay that is put up in this manner should be well settled as it is laid on the pile. After having constructed it to the proper height, rake the loose sorghum away from the sides, leaving a neat pile of hay that will turn water in case it should rain. Allow it to remain in this shape for two or three days for fermentation to take place, which is evidenced by the 'heating' and the deposit of dew upon the interior parts of the cock. When thoroughly warm and before the hay loses its natural colour, open the cocks and expose the hay to four or six hours' sun, according to the weight of the crop per acre and the size of stacks; then the hay is ready to haul to the

\* Farm Manual.

† Farmers' Bulletin No. 50, U. S. A., Department of Agriculture.

‡ Texas Experimental Station, Bulletin No. 37 (1895).

barn or be placed in stacks, where it may safely be expected to remain without moulding or heating further. If the hay is allowed to remain in the cocks too long, the fermentation proceeds too far and the hay sours and then rots in the field. It will remain longer in the cocks without damage the less of water or sap it contains when put up.....Use no salt or other applications to preserve the hay. The hay may be baled safely if given six to ten hours' sun from the cock, depending on the size of stalks."

(3) *Making into silage.*—The making of silage is such a new thing in Western India that there are very few local data available. *Jowar* has, however, been sufficiently used to make it certain that under our conditions it is very satisfactory for this purpose. Meagher and Williams\* say, from experience chiefly at Allahabad, that "sorghum of all kinds makes excellent silage—more especially when chaffed before being put into the pits."

In America, it has been used very widely indeed in this manner, and is looked upon as one of the three best crops for making silage, the other two being maize, and cowpeas (*chavli*). In that country, however, several points have been noticed in connection with its use for silage making :—

- (1) it should be allowed to be as mature as possible before putting into the silo†;
- (2) silage made from it does not keep so well as that made from maize, as it is more likely to develop acidity‡, and a very disagreeable odour;
- (3) if the crop is not put into the silo until the grain is fermed, the grain is softened and is completely digested‡.

I might call attention to a method of making silage from *jowar* in a stack silo used in the dry regions of the south west United States. It is described as follows : - "The sorghum is drawn to the stack immediately after cutting, or it may be allowed to lie in the field until it has become somewhat wilted. The stacks are heavily weighed and kept undisturbed until the process of curing has been completed : the sorghum is then cut down with the hay knife and fed to the stock as needed. The forage comes from the stack in fine condition and the loss from rotting is usually small. This method of storing sorghum has much to recommend it for the South West and the practice is growing rapidly there ; but it would probably not do so well where the climate is very moist."‡

#### *Diseases and Pests of Jowar.*

The growing of *jowar* for fodder in Western India is beset by several difficulties in the way of diseases and pests, two of which are decidedly serious. Of these the first is the growth of the *tahuli* weed (*Striga*) which is parasitic on the *jowar* roots ; the other is the *jowar* smut, which, while the most serious disease of the grain crop, affects us less when the plant is grown solely for fodder. Other diseases are less constantly serious though one or two may do considerable damage.

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\* Farm Manual.

† C. V. Piper—Forage Crops and their Culture, 1914.

‡ Williams—Farmers' Bulletin No. 50, U. S. A., Department of Agriculture.

The *Tahuli weed* (*Striga lutea* or *Striga densiflora*) is undoubtedly one of the most serious of the enemies which affect the *jowar* plant, and is termed *agio* in Gujarat. This parasitic plant occurs quite frequently in open grass land, and adapts itself very easily to growth on the roots of the *jowar* plant. Its seeds remain in the soil without germinating until in the presence of a suitable host (*jowar* by preference), they germinate, attach themselves to the root of the *jowar* plant, and draw all their nourishment from it. In presence of such roots the *tahuli* seeds will germinate even a foot under the soil. The parasite thus grows, and comes to the surface some weeks later to mature its own flower and seed. Before this takes place the *jowar* plants generally become pale in colour, and the crop is thus patchy in appearance, and if the parasite is not removed the plants remain stunted and never reach their proper height.\*

When the weed appears above the ground, a prompt uprooting and burning will remove it and clear it away, but this must be done at once. The *tahuli* may flower when occurring on poor *jowar* plants within three days of its appearance above the ground and fruit within a week. As each flower may produce two hundred seeds, the spreading is very rapid unless such uprooting is very prompt and complete. If not done promptly the uprooting may actually do harm by spreading the seeds of the weed. On large healthy *jowar* plants the plant takes much longer than this to flower and fruit, and so there is greater latitude in time for uprooting and weeding it.

It can also be dealt with by burning, passing the flame of a blast lamp (such as is used in burning the thorns off prickly-pear to be used for fodder) over the plants as soon as they appear above the ground.

The only other practical method of dealing with this parasite is a system of trap crops. *Jowar* is sown at any time, and as soon as the pest appears the crop is removed whatever its condition. This has been recommended by Pearson† in South Africa, but no sufficient tests have been made to enable us to say that it is really satisfactory in Western India.

*Smut*.—The other disease which is really of importance is the smut which affects the grain. This, though not directly of importance with the crop grown for fodder, merits serious attention, as every grower of fodder must keep a small portion of his land reserved for growing the seed of his fodder *jowars*.

The signs of the disease cannot be mistaken. When attacked by smut the grain of the whole or part of the earhead of *jowar* are turned into peculiar black powder, consisting entirely of the spores of the smut fungus. It is carried by the spores sticking to the seeds. These contaminated seeds when sown carry with them the smut spores, which germinate along with the *jowar*, grow inside the stem, and when ripe attack the earheads.

It can be completely controlled by treatment of the seed with copper sulphate. The methods of application are as follows, the account being copied from a leaflet ‡ issued by the Department of Agriculture, Bombay. It has proved absolutely successful.

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\* For these notes on the *tahuli* weed, I am indebted to articles by Van Buuren, Poona Agricultural College Reprints No. 1 (1915).

† The Problem of the witch weed, Department of Agriculture, South Africa Bulletin No. 40 (1913.)

‡ Leaflet No. 20 of 1909.

"Take 10 tolas weight of crystallized commercial copper sulphate, this will cost about two annas in the bazar: place it in a wooden or earthenware vessel and pour on to it twenty bottles of water, of the size usually used for kerosene oil (12½ *pukka* seers). Stir up the liquid with a stick until all is dissolved. The solution is now ready for use.

"Take about ten pounds of the seed which has been prepared for sowing, and put it in a bag, tying up the mouth with string. Then put the bag containing the seed into the copper sulphate solution you have prepared, and allow it to remain in the liquid for ten minutes. Then take it out and allow the liquid to drain off, pour out the seed, allow it to dry in the shade, and when dry sow it in the ordinary way. The seed should not be dried in the sun. Further lots of seed can then be soaked in the same solution in the same way."

Other vegetable parasites have not been found to do serious damage to *jowars* when grown as fodder crops in Western India.

*Insect Pests attacking jowar* :—\* While the diseases of *jowar* grown as fodder are not very important, there are one or two forms of insect attack which are very serious indeed, and demand consideration from every grower of the crop.

*Jowar Borer*.—The most important and widely distributed of these insect pests is the *jowar* borer—a caterpillar identical with that which does so much damage as the borer of sugar cane, *Ohilo simplex*. The caterpillars attack the stems, and when the plants are small, these die easily. The upper leaves on the young plant wither first, but ultimately the whole stem dies, being eaten away in the heart. The plant may tiller and thus produce new shoots from the root in well manured fields, but the growth under the best circumstances is short and bushy and of little weight compared with a normal yield. In any case a field badly attacked by the borer gives a very uneven crop.

There are several broods of the insect in the year,—three generally appear each year before the monsoon crop is harvested. The caterpillars usually spend the cold weather hibernating in the stubbles of the *jowar* or other allied crop. They may become active during the months from March to June if there is irrigated *jowar* or maize growing on which to feed. It is, therefore, a very effective method of attacking the pest to dig up all the stubbles of previous crops during the cold weather or the early part of the hot weather and burn them. This will kill all the hibernating caterpillars.

During the growth of the crop, all plants whose tops show signs of withering should be examined, and if they show signs of dead material at the heart they should be pulled up at once and fed to cattle without delay. This will partially prevent the production of the larger second and third broods.

The chief difficulty in dealing with the pest is, however, the fact that it attacks other cultivated crops, —*bajri*, maize, sugarcane, and the like,—and sugarcane in particular is a great source of infection. It is wise in fact not to allow *jowar* to be either preceded or followed in the rotation by sugarcane or maize.

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\* For the substances of these notes on insects attacking *jowar*, I am indebted to Mr. Ramrao S. Kasargode, L. Ag., Assistant Professor of Entomology at the Poona Agricultural College.



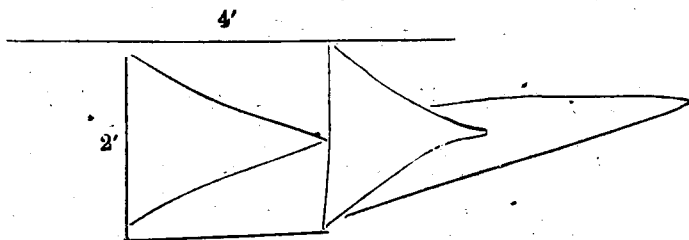
It is, however, a pest which does not lend itself at all easily to direct attack with insecticides or other similar means. It is only by constant watchfulness, by removing plants, especially early in the season, as soon as they are attacked,—by avoiding rotations which give constant food for the borer,—by digging up and burning or utilising otherwise the stubbles of the previous season's crops that one can hope to deal with this, the most serious insect attack on jowar grown for fodder.

*Jowar Grasshopper.*—Nearly all the locusts and grasshoppers will attack jowar, and in all the districts where locusts are found there are records of serious damage being done by them. But one of the wingless grasshoppers (*Colemannia sphenarioides*) has been in certain seasons a veritable pest doing very great damage to the crop at various stages. During the years from 1908 to 1912 enormous damage was done on the Deccan and Southern Maratha Country.

These grasshoppers appear as young hoppers at the beginning of the monsoon just as the seedlings of *jowar* appear above the ground. They remain active from that time until the end of September, and then lay eggs in the soil. The eggs remain unchanged in the soil until the following monsoon, when they hatch as soon as the soil again becomes moist. There is, thus, only one generation in the year, and the rabi and late sown *jowars* as well as the hot weather crop escape damage by this pest. The hoppers feed, at all stages, on the leafy growth of the plant.

There are two opportunities of attacking the pest. In the first place, the eggs can be destroyed by deep ploughing the land in the cold weather by a turn-over plough. This can be done at any time during the cold weather or the following hot weather. The only things which prevent the effectiveness of this method is the existence of *bandhs* or embankments between the plots or fields (for these cannot be ploughed up), and the presence of uncultivated land round the fields in which *jowar* is planted. The grasshoppers freely lay eggs in such *bandhs* and in such uncultivated land.

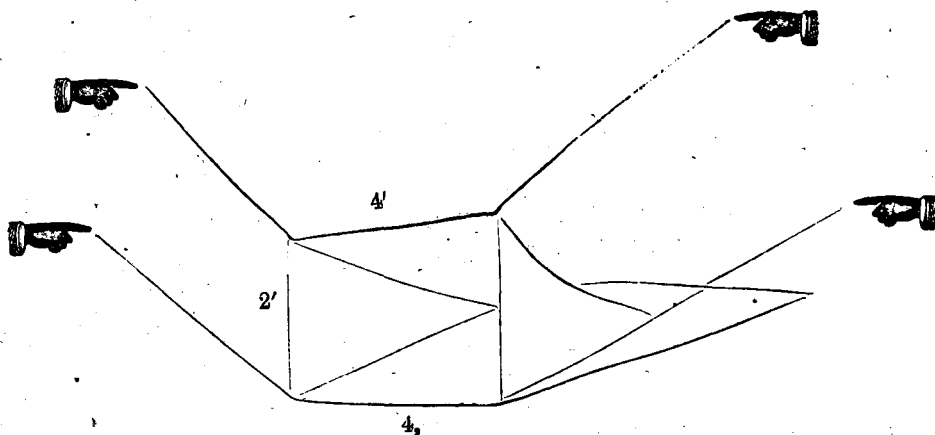
In the second place, the young hoppers can be caught in nets or bags described as follows:—Sufficient strips of coarse country cloth are taken 12 feet long, sewn together so as to make a piece 12 feet long and 6 feet wide. The two ends of this are then brought together, and the sides sewn up. This makes a bag 6 feet square. To the mouth of the bag 12 strong tags are sewn at intervals of one foot apart. A thin cord should be sewn round the mouth of the bag, so that no strain will come on the cloth when the bag is dragged over the field. The mouth of this bag can now be attached to a frame made of four pieces of bamboo or light wood and strongly tied together with country twine. The appearance of the bag thus made is shown in the figure below.



NO. 1. BAG FOR CATCHING HOPPERS.

This frame with the bag attached is then drawn by two men up and down the field, sweeping up the hoppers in its path. The hoppers are caught in the bag in immense numbers, and can then be destroyed by putting in kerosene and water. It is very useful in grass lands, and in young or low crops. In an experiment, by the use of three of these bags for seven hours, no less than 14 lakhs of insects were captured, weighing 80 seers.

In the case of high crops, when the above may damage the crop, then the frame described is not used, and the mouth of the bag is simply kept open by means of two pieces of wood or bamboo two feet at the sides, as shown in the figure below, and is then drawn over the field by two men with cords.



No. 2. BAG FOR CATCHING GRASSHOPPERS (2ND FORM.)

This process will clear an acre of young *jowar* from hoppers in a day using two men and a boy. The bag will cost Rs. 2-8-0 to Rs. 3-8-0.

Other pests of fodder *jowar* like the aphid which appear on the young plant are not of serious importance.

## Feeding Value of Jowar Fodder.

I have examined many samples of fodder from *jowar* plants, both green and dry. All of them contain between fifty-five and seventy per cent. of water when green and they usually give about forty-five to fifty per cent. of fodder dried enough to keep well. As would be expected, the heavily irrigated hot weather *jowars* contain most water when cut. Calculated to an equal basis of sixty per cent. of water, some of these *jowars* grown on the College Farm, Poona, in 1912, at the stage at which they would usually be cut, yielded the following figures, which may be taken as typical of their character:—

	Sundhia	American sorghum.	Nilwa.	Hundi.	Utavli.	Shalu.
	p. c.	p. c.	p. c.	p. c.	p. c.	p. c.
Water	60.0	60.0	60.0	60.0	60.0	60.10
Ether Extract (oil, &c.)	0.6	0.6	0.6	0.6	0.6	0.6
* Albuminoids (i. e. nitrogen $\times 6\frac{1}{2}$ )	2.0	1.3	1.5	2.3	1.4	1.8
Digestible carbohydrates	21.9	20.1	20.3	23.5	20.5	21.6
Woody fibre	12.5	14.9	14.6	11.1	14.3	12.9
Ash	3.0	3.1	3.0	2.5	3.2	3.1
	100.0	100.0	100.0	100.0	100.0	100.0
* Containing nitrogen	0.32	0.20	0.24	0.34	0.22	0.28

Another year the dried fodder prepared at the College Farm of these types of *jowar* gave the following figures, the actual figures being calculated to material containing ten per cent. of water:—

	Utavli.	Nilwa.	Khondi.
	p. c.	p. c.	p. c.
Water	10.0	10.0	10.0
Ether Extract (oil, &c.)	1.8	1.5	1.2
† Albuminoids (i. e., nitrogen $\times 6\frac{1}{2}$ )	6.4	5.7	5.9
Digestible carbohydrates	41.9	41.6	43.5
Woody fibre	33.4	32.8	32.8
Ash	6.5	8.4	6.6
	100.0	100.0	100.0
† Containing nitrogen	1.0	0.9	0.9

It is interesting to compare with these the analyses of American sorghums as obtained in the United States. Very many of these have been done, but I take two or three typical sets. I have calculated all to a constant content of moisture of 10 per cent :—

	Amber sorghum in bloom.	Amber sorghum seed forming (milk stage.*	Average of 31 analyses. †
	p. c.	p. c.	p. c.
Water	10.0	10.0	10.0
Ether extract (oil, &c.)	5.3	4.5	5.4
‡ Albuminoids (i.e., nitrogen x 6½)	6.2	4.9	4.8
Digestible carbohydrates	41.1	49.7	49.9
Woody fibre	32.3	26.3	24.5
Ash	5.1	4.6	5.4
	100.0	100.0	100.0
‡ Containing nitrogen	1.0	0.8	0.8

Two other analyses, from another part of the United States, give figures not widely different from these, as follows :—

	Dried jowar plants (heads just appearing. §	Dried jowar plants (seed just forming). §
	p. c.	p. c.
Moisture	10.0	10.0
Ether Extract (oil &c.)	3.1	1.9
¶ Albuminoids (i. e. nitrogen x 6½)	9.0	6.4
Digestible carbohydrates	36.0	42.3
Woody fibre	31.8	30.4
Ash	10.1	9.0
	100.0	100.0
¶ Containing nitrogen	1.44	1.02

\* Georgia Experiment Station, Bulletin No 13 (1891).

† Farmers' Bulletin, U. S. A., No. 50.

§ Thatcher. Report of Nebraska Agricultural Experiment Station, 1900.

Though the special value of *jowar* fodder is not brought out by these figures, yet they show that *jowar* plants cut at the proper time are very similar in chemical composition to other members of the gramineae, cut at a similar stage. The material is, in fact, approximately of the quality of maize fodder or of good class hay made from grass, cut at flowering. The only objection made against *jowar* fodder is that the joints in the stem are hard, and are wasted by the animals. This is partly true with the coarser varieties, and when the fodder has been cut too ripe. But with the finer types of *jowar* fodder, such as *sundhia*, there is little objection on this score if the material is chaffed before being fed to animals. Chaffing seems essential if waste is to be avoided and the best value obtained from the fodder.

#### IV. MAIZE.

As a producer of fodder, maize probably stands only second to *jowar* among the crops of the world, and it may even be doubted whether it is not in many cases considerably its superior. It produces almost as much good fodder per acre as *jowar*, it can be safely grown over a larger range of country than its rival, and it can be fed at any stage of its growth far more safely than is the case with *jowar*.

##### *Climate Required for Maize.*

The country where maize growing has developed to a greater extent than anywhere else in the world, both for grain and for fodder, is the United States of America. There, it is the premier crop of the country, and dominates the agriculture of a vast area of land extending from semi-tropical conditions to those with a very hot summer and a very cold winter. Of course there are an almost endless number of varieties suited to these varying conditions, some ripening quickly, some slowly, some yielding grain and little fodder, some much fodder and relatively little grain. But the general result of a consideration of its range in the United States shows that maize is one of the most-tolerant of crops so far as climatic conditions are concerned, more especially when it is grown for fodder. It will not stand frost, and does not grow rapidly below about 60° F, but so far as temperature is concerned it will do well wherever the mean is above this point (60° F.) during the growing period. As to rainfall, it does not seem to flourish where there is a combination of high temperature and heavy rainfall so far as giving a high yield is concerned. Most of the best part of the great maize area in America has a rainfall ranging from 30 to 40 inches per annum. But provided it has not to stand waterlogged conditions, maize is capable of growing for the production of fodder under very widely different conditions of rainfall.

In India, where maize is a crop introduced comparatively recently,\* its cultivation has not extended so widely as one would have expected. It has become a dominating crop, however, among the hill peoples of Northern and Central India, and is grown, moreover, on much of the plains also in the northern part of the country. In the Peninsula, apart from such hill areas, the cultivation has hardly spread. In the Bombay Presidency, two-thirds of the total area is in one district the Panch Mahals, chiefly inhabited by hill tribes.

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\* See Watt—Commercial Products of India.—*Zea mays*.

But enough is grown to show (1) that maize, at any rate for fodder, will flourish in almost any part of Western India, (2) that, given suitable soil, there need be no fear of planting it as a fodder crop, whenever water is available, either from natural or artificial sources.

#### Varieties of Maize.

Experiments have been conducted with various types of maize, both transferred from district to district, and imported from America, but in no case has a variety been obtained that, for fodder production, has been any improvement on that already locally grown. At present the varieties here have not been closely studied, but everything seems to indicate that the intending cultivators cannot do better than utilise good seed from the district nearest to his farm where maize is grown.\*

The results of growing maize for fodder have been more completely worked out on the Deccan, by experiments at Poona, than anywhere else, and the yields obtained in a number of years, on well manured lands are as follows when the plant was grown as a rains crop and usually without irrigation. I have recalculated all the results, where necessary, to a basis of dry fodder, counting one pound of dry to be produced by  $2\frac{1}{2}$  pounds of green fodder.

Year.	Yield of dry fodder per acre.	Cost of production.	Value of Crop on sale.	Remarks.
	lbs.	Rs. s. p.	Rs. s. p.	
1893	7,940	29 0 0	59 0 0	Green fodder valued at 300 lbs. per Rupee.
1894	13,650	23 0 0	94 0 0	Green fodder valued at 325 lbs. per Rupee.
1898	11,675	20 5 0	88 0 0	
1904	8,970	26 0 0	67 0 0	Affected by long break in rains and therefore irrigated.
1905	6,800	55 0 0		Had to be irrigated.
1908	9,500	34 0 0		

These figures give an average yield of 9,700 pounds or about  $4\frac{1}{2}$  tons of dry fodder per acre on well-manured land. This is just about equal to the yield of *sundhia jowar* under similar conditions. It is fully understood that this is only obtained on well manured land; the yield rapidly falls off if the manure is omitted.

Maize has the great advantage over most types of *jowar* that it can be grown in the Deccan at almost any time of the year provided irrigation is given. The yield is, of course, usually smaller, but the fodder is

\* Poona Farm Report, 1898, states "Several American varieties were tried but neither in growth of stalk nor in size of cob were they so good as the common country varieties." See also Meagher and Williams--Farm Manual.

correspondingly more valuable. Some yields actually obtained on the Poona Farm in the hot weather, and in the *rabi* season were as follows\* :—

Year.	Yield of dry fodder per acre.	Cost of production.	Value of crop.	Remarks.
		<i>Hot weather.</i>		
	lbs.	Rs. a p.	Rs. a p.	
1904	8,700	48 0 0	65 0 0	
1908	11,200	151 0 0		February to May.
1910	10,700	152 0 0		Do.
		<i>Autumn and cold weather.</i>		
1905	4,500	17 0 0		Following manured maize and sown on September, 29.
1909	8,300	43 0 0		December to February.
1911	5,980	30 0 0		Do.

As a further illustration of this most valuable character of maize as a fodder crop—that it can be grown in the Deccan at almost any season—the result of an experiment at Manjri may be given where a succession of maize crops for fodder on land manured with 2,000 pounds of safflower cake per acre were taken. The results were as follows—the yield being given as green fodder :—

		lbs.
1st Crop	June to August	18,308 per acre.
2nd Crop	September to November	7,031 "
3rd Crop	December to February	11,625 "
4th Crop	March to June	8,698 "

Total 45,662

This is equivalent to 20,300 pounds or over 9 tons of dry fodder per acre in the year, costing Rs. 183.

The figures here given have been obtained from experiments on the medium black soil on the Deccan, but it is now known that maize will grow very well as a fodder crop in most other parts of Western India, including Gujarat and the Konkan. In the latter case (the Konkan) it gave a yield at Ratnagiri † of 12,560 pounds of green fodder per acre in the hot weather worth Rs. 62-8-0.

#### *Cultivation.*

Just as with the fodder jowars, maize should be grown thickly—much more thickly than if it was intended to sow it for grain. Mollison‡ recommends that it should be sown with a four coultered drill, with rows

\* These results will be found in the Reports of the Poona and Dairy Farms, Poona.

† Report of the Ratnagiri Agricultural Station, 1913-14.

‡ Text-book of Agriculture, Vol. III, p. 53.

about twelve to thirteen inches apart—and states that twenty pounds of seed per acre are sufficient. As a rule, however, it is well to sow more thickly than this and keep a distance of only nine inches between the rows, sowing either with a drill or after the plough and using fifty to sixty pounds of seed per acre. If this is done the land should be well cultivated before sowing, and then little or no interculture will be necessary while the crop is growing. The thicker sowing not only ensures a thicker stand of plant, but also tends to prevent the fodder becoming coarse.

*Soils for Maize Fodder.*—Maize will grow in almost any kind of soil in Western India, provided that there is good drainage, and hence that the land is not waterlogged. The ideal land is, however, a light loam of considerable depth, and this crop does not need the stiff tenacious soil which seems the best for growing fodder *jowar*. It is curious to see how rapidly maize replaces *jowar* under irrigation in the South Deccan, where, as in the neighbourhood of Gokak, a black soil gives place to light land derived from sandstone rocks.

*Methods of Cultivation.*—The methods of cultivation which have proved best are very similar to those used for *jowar*. As with this latter crop, maize does not require deep cultivation, and in fact seems to give a bigger return if deep cultivation is not carried out. This is in accordance with experience in America.\*

In the case of the crop to be sown chiefly or entirely on the monsoon rains, the land should be ready for sowing by the middle of June. The soil should be prepared in the hot weather if possible, and should be ploughed shallow or deeply harrowed, and subsequently harrowed repeatedly so as to produce a thin layer of loose soil on the top. It should be well manured with cattle manure before ploughing. Maize repays manuring and the best manure is farm-yard manure.† It will usually pay to apply eight to ten tons per acre of cattle manure. It is rarely advisable or necessary to use concentrated artificial manures, but (as above indicated) four good crops in succession have been obtained after treatment with two thousand pounds of safflower cake per acre. The crop, further, grows excellently on sewage effluent‡. The crop is not usually intercultured, if the soil has been well prepared, but interculturing will usually do good if the time and labour is available, if done once or twice after the crop is four or five inches high. It is not so necessary as with *jowar*, because the maize grows quicker and smothers the weeds more completely.

In the case of maize grown at any other season, the land should be well prepared, and if possible frequently harrowed before sowing the maize. Sowing should be done as with the monsoon *kharif* crop, and, immediately after the seed is covered, beds should be made as a provision for irrigating the crop. The beds should be long and narrow, five feet wide. The length of course, depends on the levels in the field, as they must be level for irrigation. Interculture is valuable with an irrigated crop as it tends to form a good soil mulch and so reduce surface evaporation.

\* See, for example, Shepperd and Churchill—Bulletin No. 76, N. Dakota Experiment Station.

† Maize well manured gives a better fodder containing less fibre and twenty-five to thirty per cent. more proteins than when unmanured. See Snyder,—Minnesota Experiment Station, Bulletin No. 101.

‡ Kelkar—Bulletin No. 84 (1909), Bombay Agriculture Department, p. 9.



Maize is not usually sown as a mixed crop for fodder purposes, except in one case. This is when a little maize is sown in sugarcane fields on the Daccau, immediately after the cane sets are planted. It is, of course, removed long before the principal crop shades the ground. The practice is distinctly a good one.

*Rotations.*—The rotations suitable for maize are nearly the same as those for *jowar*. In the Panch Mahals, wheat is often taken after maize, and this is hardly good practice. Gram would be much better,\* and is very often used, though hardly so frequently as wheat.

#### *Utilisation of Maize Fodder.*

Maize grows very rapidly, and has one great advantage over all the *jowars* namely that it can be fed to stock at any period of its growth. There has never been any charge of injury to animals by eating young maize which could not be explained by a sudden access to large quantities of succulent green fodder,—which is always dangerous. Careful experiments have been made in America to see if prussic acid—the poison of young *jowar* fodder—is ever to be found in maize and it has never been detected even in suckers from the maize stalks in the field†.

This being the case, the crop when grown for fodder can be cut and used at any stage that is most convenient, but the maximum yield and digestibility together is obtained if it is cut when the grain is in the dough stage—whether intended for direct feeding, for making into hay, or for making silage. The method of cutting almost universally used here up to the present is the sickle, and with maize this method is so good that it is still very largely used even in America. If sown thick, however, as above recommended, the crop can well be cut with the ordinary mowing machine.

Under the conditions of Western India the crop is usually ready to cut about two months after sowing. Moderate changes in temperature do not seem to have very great effect on the yield of maize fodder per acre,‡ but naturally in the cold weather the time taken for growth is longer. Except between November and February the crop should not, however, take much longer to mature for fodder than the time above indicated.

Maize is probably the best emergency fodder crop to grow when the rain fails, as is so often the case in Western India, and when famine is imminent. It grows quickly, it requires little water considering the yield of fodder which it gives, and it can be cut at any stage without danger.§

*Utilisation.*—In Western India the fodder maize crop, in the few cases when it is grown, is usually cut in the field and fed green to stock direct. When grown in the hot weather, it is the only way of using it. If it is to be employed in this way, it is specially important to grow it thickly on the field. Otherwise the lower part of the stalks become very coarse, and

\* Mollison.—Text Book of Agriculture, Vol. III, page 52.

† Alway and Trumbull—Nebraska Agricultural Experiment Station Report, 1909.

‡ Burti—Davy.—Transvaal Agricultural Journal, Vol. VII (1909).

§ See Leaflet No. 5 of 1911. Bombay Department of Agriculture.

the lower leaves become decidedly fibrous.\* When grown thickly this does not occur, and the fodder is very good. Mollison states "The green fodder is excellent, being very sugary."† It will hardly, however, fetch as high a price as *sundhia* on the market.

The digestibility of green maize fodder as a whole, does not materially decrease until the dough stage is reached. According to American tests with sheep, the following percentages of digestibility were obtained from immature fodder, and fodder at the above stage.‡

	Percentage digested.			
	Proteids.	Fat.	Nitrogen-free extract.	Fibre.
Immature fodder . . .	47.4	45.9	57.6	67.9
Fodder at dough stage . . .	36.0	66.1	60.6	56.7

This would indicate that as the crop becomes ripper it loses in digestibility so far as proteids and fibre are concerned, but not otherwise. Cattle digest all the constituents rather better than sheep. Experiments by the same workers as those above quoted indicate that in the best types of fodder *jowar*, the proteids, the fibre, and the nitrogen-free extract are rather more digestible than in mature maize. The difference, however, is not great except with the proteids. Other experiments are even more favourable to maize fodder.

Green maize should be well cut up before being given to cattle, as already described with *jowar*. The cutting up is even more important than with the best types of *jowar* fodder.

If maize is allowed to ripen completely, so that the cobs of grain can be taken, the fodder loses much in value, far more than *jowar*. It is hardly fit, indeed, to give to cattle unless mixed with more nutritious fodder. In America, it is often regarded as useless, and is left standing in the fields or burnt. In India Meagher and Williams§ state that it "makes an inferior fodder when fed after the cobs have ripened, and should be fed only to working cattle when mixed with other fodder." The fact that maize fodder so largely loses its value if left till the grain is mature should never be forgotten. In case maize is grown for seed it is a common practice in India to strip the leaves for fodder during growth, as this is said also to improve the seed.

In India, maize has not usually been made into hay, that is to say, cut when in the dough stage, dried in the field, and stacked. When there is no chance of making silage, however, very satisfactory feed can be produced by this method, and huge quantities of maize hay are made in America. To preserve it in this way, the crop should, after cutting, be bound in sheaves eight to twelve inches in diameter, and five or six of these made into an open but firmly built shock in the field, the tops being bound together to lend further strength. These shocks if well made will stand in the field as long as it is wished to leave them there, or they can be carried to the farm and stacked loosely¶.

\* See Poona Farm Report, 1893.

† Text Book of Agriculture, Vol. III, page 52.

‡ Headen—Colorado Bulletin No. 93.

§ Farm Manual.

¶ See Gridale-Corn for Ensilage and the Silo, Ottawa, 1912.

But if maize is to be kept, the ideal method of keeping it is the silo. It is the ideal crop for silage, and the crop to which this method of preserving has been applied to by far the greatest extent. We have comparatively few data for Western India with regard to the yields obtained but it has been sufficiently used to show that the fodder produced by this method is excellent and that the losses are comparatively small.

The maize, for silage making should be cut when the grain is in the dough stage as before, or perhaps when a little riper\* and immediately taken to be cut up for the silo. It can be put in the silo without chaffing, but it means a larger loss from the material becoming mouldy. The better the material is cut up the better, and some authorities even recommend cutting it into half-inch lengths.

It forms excellent silage either in built-silos or in pit-silos. The former are, of course, the most suitable for large farms, but a simple pit in the ground eight or ten feet wide and four to six feet deep, free from any chance of drainage into it, into which the cut maize is put and trampled down carefully especially near the sides, has given very good results. After filling, the whole is then covered, weighted with earth, and the fodder is ready for use after three months, though it may be kept for a year or more.

So prepared it gives a splendid fodder for the long dry weather of Western India. The digestibility is very little affected (see page 47) by making it into silage, and it is eaten greedily by stock.

#### *Diseases and Pests of Maize.*

"Maize is the food plant of a great number of insects which rarely do it serious injury: only where it is grown in small quantities and is not the staple crop do these pests become so numerous on each plant as to do much damage."†

*Maize Borer.*—The only really serious pest is the moth borer, which under the name of the "jowar borer" has already been described when considering the *jowar* crop. The chief difficulty in dealing with this borer is the fact that it attacks so many cultivated crops.

When it appears, however, all young maize stems which show signs of being attacked should be removed and burnt, and in any case the stubbles of the crops should not be allowed to remain standing in the land. They should either be removed, and burnt or otherwise utilized as soon after the removal of the crop as possible.

*Maize Fly*—(*Delphax psylloides*).—This small dark insect, not unlike a large aphid, is found in the sheathing leaves of maize. "The insects are active, running crab-like with a side ways motion, and leaping away when disturbed." "Large colonies of all ages are found in infested plants and feed by extracting juice from the tissues of the plant."† The insect sometimes, though not usually, does a good deal of damage to small plots of maize. It can usually be checked by dropping ashes or lime and kerosene into the heart of the plant to drive out the flies.†

\* Morse (New Hampshire Agricultural Station, Bulletin No. 92) says "The corn (maize) plant has reached its maximum food production when it is nearly matured, with the ears fully formed and well filled, and at this stage it is best suited for silage."

† Lefroy—Indian Insect Pests.

Other insect pests have been so far of no practical importance in Western India.

No fungus or other vegetable pest has yet done serious injury to maize in Western India, when grown as a fodder crop.

*Feeding Value of Maize Fodder.*

Maize when cut at the stage suggested, usually contains between 70 and 80 per cent. of water, and most often over 75 per cent. There is a tendency, judging from the published analyses, for maize fodder to be more watery in colder climates than it is in Western India. Thus for instance in England it contained, as the average of numerous analyses, 83·2 per cent. of water, the amount being greater in bad seasons than in good ones. At the same time large well-grown, advanced plants always contained less water than smaller ones which had not grown so vigorously.\* In Italy similar fodder contained 79·3 per cent. of water.† Our results for maize fodder grown at and near Poona gave (1) 77·9, (2) 76·1, (3) 72·3 per cent. of water.

Calculated on an even basis of 75 per cent. of water, maize grown at Poona and Manjri in 1912, 1914, and 1915 gave the following figures on analysis:—

	(1)	(2)	(3)	(4)
	%	%	%	%
Water	75·0	75·0	75·0	75·0
Ether Extract (oil, &c)	0·5	0·4	0·5	0·6
*Albuminoids (i.e. nitrogen x 6½)	1·5	1·3	1·3	1·7
Digestible carbohydrates	14·0	15·2	14·0	13·1
Woody fibre	7·6	6·7	7·3	7·3
Ash	1·4	1·4	1·9	2·3
	100·0	100·0	100·0	100·0
*Containing nitrogen	·23	·20	·21	·24

It will be seen that, calculated on a similar basis of water the composition of this maize fodder is not widely different from those of *jowar* already reported (see page 37). Very little alteration in composition and very little change in digestibility occur if the fodder is dried.‡

In making silage a considerable loss of digestible carbohydrates, including sugar takes place. I quote analyses made of silage prepared at the Gokak Farm and in England calculated to a basis of 75 per cent. of water.

\* Annett and Russell—Journal of Agricultural Science, Vol. II (1908).

† Feruglio and Mayer, 1909.

‡ See Lindsey—Massachusetts Agricultural Experiment Station Report, 1904. The conclusion is based on experiments on sheep.

	I Maize silage, Gokak Farm, %	II Maize silage* England. %
Water	75.0	75.0
Ether Extract (oil, &c.)	0.8	0.7
† Albuminoids (i.e., nitrogen $\times 6\frac{1}{2}$ )	2.3	2.8
Digestible carbohydrates	11.3	10.4
Woody fibre	8.0	9.3
Ash	2.6	1.8
	100.0	100.0
† Containing nitrogen	·36	·45

Numerous experiments have been made to ascertain whether the making of silage reduces or increases the digestibility of the constituents of the maize and on the whole it seems that the digestibility is somewhat reduced. I will quote the results of two sets of experiments, both conducted with cattle, and both done in America.

*Percentage of Constituents digested.*

	Proteids.	Fat.	Nitrogen-free extract.	Fibre.
(1) † Maize fodder ...	56.9	72.3	74.4	79.8
Maize silage ...	46.7	68.3	64.1	67.2
(2) § Maize fodder (green) ...	73.5	83.0	76.1	75.3
Maize silage ...	66.2	82.5	71.9	74.2

From these figures it would appear that making the fodder into silage reduces considerably the digestibility of the proteids, but that of other constituents is less affected.

In spite of all, however, the general opinion appears to be that the making of silage is by far the best method of preserving maize for fodder, and that it is usually well worth while to preserve it by this system.

It has been stated that good silage can be made from dried maize fodder, by mixing it with water and closing down the silo in the usual way, and that if there is not excess or accumulation of water the fodder keeps very well and is greedily eaten by stock.¶ We have no experience, however, of this method in Western India.

\* Annett and Russell—*loc cit.*

† Bartlett—Maine Agricultural Experiment Station, Bulletin No. 110.

§ Gamble—Annual Report, Ontario Agricultural College, 1905.

¶ Neale—Delaware Agricultural Experiment Station Report, 1903.

## V. BAJRI AND OTHER MILLETS.

The crops so far dealt with the various types of *jowar* and maize, represent the best gramineous annual fodder crops for general use in Western India, which are known at present. In many cases, however, rapidly growing crops are needed for lighter land than suits either of these, especially when very heavy rain occurs, and also for a variety of other conditions. For these conditions *bajri* and other millets have been employed in the past, and are used at present. It is important to consider their advantages, and disadvantages as well as the methods of cultivation which have proved most useful.

### BAJRI.

*Bajri* (*Pennisetum typhoidem*) or bulrush or cat-tail millet is one of the two chief grain crops in Western India, and incidentally produces a very large amount of fodder, as the straw remaining after the removal of the grain is much used for feeding stock. In this form, though widely employed it is looked upon as considerably inferior to the *kabdi* or straw of *jowar*. But as the crop producing this straw is grown mainly for grain, the fodder so produced will not be considered in the present study. *Bajri* is very little cultivated purely as a fodder crop, and probably rightly so. It is, however, occasionally so grown in Upper Gujarat, though it there seems to possess practically no advantages over *jowar* or maize; and also sometimes in river beds on account of its very rapid growth under these conditions.

*Bajri* is almost always a crop of the rainy season, and whether grown for grain or for fodder it is produced on the monsoon rain. It does not seem able to stand very heavy rain, and "does best when the climate is moderately dry and when the monsoon rain comes in light downpours and there is plenty of sunshine between showers. Heavy rain is disastrous to germinating seed or young seedlings, and later, when the crop has made some progress, it is checked in growth and turns yellow during heavy continuous rain. In the Deccan the sowing of *bajri* is purposely delayed until the middle of July in order to avoid, as far as possible, the risks referred to above" (Mollison). The rain does not exceed forty inches per annum in any of the *bajri* districts. It is also a crop of light and well drained soil, being only grown on alluvial soils; on higher and more porous land, and on the lighter forms of black soil.

Under the conditions which it prefers, *bajri* will grow very quickly, and yield very heavily in fodder, giving in some cases more fodder than the *jowars* and producing it almost as quickly as the best of these. In 1896, grown thickly, it gave 10,300 pounds or over  $4\frac{1}{2}$  tons of dry fodder per acre on medium black soil at Poona, costing Rs. 23 per acre, the fodder being worth Rs. 34 per acre. It was sown on June 29th and was reaped in full flower on September 18th, or after 81 days. This was a yield practically equal to *sundha* *jowar*, but not equal to *nilwa*. In the same year on light land it gave a yield of 9,011 pounds per acre, or practically an equal yield to *nilwa* which produced 9,149 pounds per acre. These are the conditions which it prefers, and on which relatively the best results will always be obtained.

In the United States even better results as to yield have been obtained than with us. There it is never grown for grain and is considered as perhaps the most heavy yielding of fodder crops of this kind,\* especially when repeated cuttings are taken from the plants, a practice which has hardly been

\* Pipes—Forage Plants, page 302.

adopted here. Yields as high as 94,000 pounds of green fodder per acre in six cuttings (beginning from fifty-four days after sowing) have been reported from South Carolina,\* or 80,000 pounds in two cuttings from Kentucky. In the last named State 32,800 pounds of dry fodder have been obtained per acre, and our yields at Poona above given are exceeded in a number of other places. When a real drought occurs during growth, it has, however, been less resistant than *jowars* (sorghum†); and the same experience has been found in Rhodesia‡ for most of the varieties available.

In spite of its large yield, however, it is less and less grown in America, being replaced more and more by *jowar* (sorghum) and maize, owing to the relatively inferior character of its fodder. The opinion is, in fact, very similar to what was expressed by Mollison in 1896 (*loc. cit.*) as follows. "When sown thickly it yields heavily, but, though the stalks grow thin, the fodder is of inferior description. I infer this because neither well-fed milch cattle nor work cattle like it." This is essentially the objection to *bajri* as a fodder crop. It yields splendidly, but the fodder is poor stuff. The green fodder was, in fact only worth half the value of *milwa* on the Poona market, and it may be considered as more profitably utilised when employed to grow grain and fodder than when used to produce fodder alone. If it is desired to grow *bajri* for fodder in places suitable to it, one of the Gujarat varieties (*malbandro* or *deshi*) should be employed and it had better be sown thickly as already recommended for fodder *jowar*, and grown only as a rains crop. It will need from fifteen to twenty pounds per acre of seed, and with favourable rains will be ready to be cut in full flower in from sixty-five to eighty days after sowing. A better method, probably of utilising the fodder is to cut before this stage, when the flower stalk is only appearing, and then take fresh cuttings as the plants grow up again. There is no danger of feeding the material cut at this stage, as would be the case with *jowar*.

We have no experience in Western India in the use of fodder *bajri* except for feeding green to animals. It is said to be difficult to make into hay, and to be less suitable for silage than maize or *jowar*, but I am not aware of any local attempts to utilise it in either of these ways. It would appear to be worthy of trial for silage making, being cut very young, and repeated cuttings being obtained from the plants.

*Bajri* grown at the Agricultural College Farm, Poona, and cut green, gave on a basis of 60 per cent. of water, the following composition on analysis (1912-13) :—

	Per cent.
Water	60.0
Ether Extract (oil, &c.)	0.4
† Albuminoids ( <i>i.e.</i> , nitrogen $\times 6\frac{1}{2}$ )	1.3
Digestible Carbohydrates	20.0
Woody fibre	15.8
Ash	2.5
	<hr/>
	100.0
	<hr/>
† Containing nitrogen	0.21

\* Garrison—S. Carolina Agricultural Experiment Station, Bulletin No. 123 (1906).

† Connor—Texas Agricultural Experiment Station, Bulletin No. 132 (1911).

‡ Kenny—Rhodesia Agricultural Journal, Vol. VII (1910).

## KANG OR RALA.

*Kang or Rala (Setaria italica)* or foxtail millet is a minor grain crop in very many parts of India, and is occasionally grown in Gujarat as a fodder crop. It has certain advantages which make it worth considering, in spite of its giving a small yield in comparison with those crops we have already considered. Its principal advantage is that it will give a very rapid crop of fodder, that it will grow most successfully in the hot weather, and that it gives material very palatable to animals. It thus has a special value as a catch crop when the time is not long enough to grow the more heavy yielding crops.

The amount of local information about the crop is meagre, at any rate when cultivated for fodder alone,—and the information which can be given is chiefly gathered from foreign sources. The seed used here will, however, be one of the common country varieties, as the foreign ones (German, Hungarian, or Siberian) have never been introduced. But it is stated by Duthie, of the common variety, that its “abundant and nutritious foliage yields an excellent forage, if cut when in blossom.”

As at present grown for grain, chiefly in the Southern Maratha Country, the crop is sown with a drill, in rows twelve to fourteen inches apart at the rate of six to ten pounds of seed per acre, and is put in the land in July to August. At this time of the year, it has, however, no advantage over other more productive fodders. Its use is in the hot weather, and at this time it had better be sown broadcast or in rows much closer together (say eight or nine inches). The seed required is ten to twelve pounds per acre. The crop is ready for cutting in about one and a half months, and on good soil will give plants standing five to six feet high, and yielding from six to eight thousand pounds of green fodder per acre.\*

An attempt has been made at Nadiad (Gujarat) on light alluvial land to sow it for fodder from October to April.† In the cold weather it grows much more slowly, and is not fit to cut for nearly three months—the actual average being eighty one days—but as the weather becomes warmer the growth is marvellously rapid. The yields obtained at various dates of sowing, and other particulars are shown in the following table, being the average for two years:—

Date of sowing.	Yield of dry fodder.	Length of time growing.	Cost of crop.	Number of irrigations required.
1912 and 1913-14	lbs.	days.	Rs. a. p.	
August 22‡	1,840	55	23 0 0	None.
September 15‡	2,880	53	52 0 0	5
October 15 or 16§	4,360	68	53 0 0	4 to 5
November 1	5,120	74	54 12 0	4
November 15§	5,336	82	56 0 0	5 to 6
December 1	5,920	75	61 0 0	4
December 15	3,720	87	56 8 0	5 to 6
January 15‡	4,400	70	56 0 0	6
February 15‡	4,000	65	71 0 0	8
March 15‡	5,800	53	50 0 0	5
April 15‡	4,400	39	51 0 0	5

\* Kelkar in Leaflet No. 5 of 1911 of the Department of Agriculture, Bombay.

† Report of the Nadiad Agricultural Station, 1912-13 and 1913-14.

‡ 1913-14 only.

§ 1912 only.



This shows an average return of dry fodder in the cold weather (*i.e.*, sown in October to January) of 4,800 pounds, and in the hot weather (*i.e.*, sown in February, March or April) of nearly 4,700 pounds of dry fodder per acre. It is a question, however, how far it is of advantage in the cold weather over *shahu jowar*, especially as the least sign of frost ruins the crop and slight frost is not infrequent at the end of January in North Gujarat.

The crop grown on the Agricultural College Farm, Poona, had a composition, when green, calculating on a basis of 60 per cent. of water, as follows:—

Moisture	60.0
Ether Extract (oil, &c.)	0.8
* Albuminoids	2.1
Digestible Carbohydrates	20.8
Woody fibre	12.2
Ash	4.0
	100.0
* Containing nitrogen	0.34

This shows a fairly high percentage of nitrogen.

Whenever grown here in the past it has been for feeding green to the stock, and it has not been used for making hay or for silage. Elsewhere it is found to yield good hay if cut just before blooming, or, if for cattle or sheep, it may be left till the seeds are in the late milk stage of development.† In the latter case, however, the hay is inferior. For silage making it is not very good, but gives nevertheless a product which animals eat greedily.

The fodder derived from *rals* is stated in America to be injurious to horses when largely used, but no injury has ever been suggested as being done by it to cattle or sheep.

#### CHENO AND SIMILAR MILLET CROPS.

A number of small millets well distinguished from one another by the people, but all belonging botanically to the species *Panicum miliaceum* and *Panicum miliare* are known variously as *cheno* (Gujarat), *vari* (Deccan), *gajro* (Panch Mahals) or *sava* (Marathi). These crops are chiefly cultivated as an inferior grain crop, largely on the poor lands with higher rainfall below the Western Ghats, and in the *Dang* country. I shall consider, for our present purpose, the various fodder crops under these titles as one—as there is great confusion in the naming of the types used and for fodder purposes they may perhaps be classed together.

As an essential fodder crop these millets are at present only grown in Gujarat and the cultivation there has been well described by Mollison as follows:—†

† Piper—Forage Plants.

† Text Book of Indian Agriculture, Vol. III, page 64.

"*Cheno*—This crop is grown principally in Gujarat, chiefly in garden land, and as a hot weather, irrigated crop. The cultivation of *cheno* in Gujarat is popular, because it thrives well in the hot weather. It then provides excellent fodder in considerable quantity at a season when fodder is scarce. The cultivator of garden land is, in the hot weather and at the beginning of the rains, often hard pressed for fodder for his milk cattle, because his energies are chiefly directed to producing market garden crops, which, though very valuable, do not help him to feed the cattle which he requires for tillage and irrigation. In the Charotar villages of Baroda and Kaira *cheno* often follows ginger or other market garden crops which come to maturity in December-January.

"When the ginger or other market garden crop is removed, the land is ploughed several times. When a good tilth is produced, beds are formed for irrigation. The seed at the rate of ten pounds per acre is carefully broadcasted, and lightly covered. Light irrigation is given as required. The crop is usually handweeded once. If sown at the end of January, it comes into flower in March, and may then be cut green for immediate requirements."

Grown in this fashion *cheno* may be expected to yield, on fairly rich land a crop of six to seven thousand pounds per acre of green fodder after growing for six to seven weeks,\* and this is by far the most useful method of growing the crop. It grows even more quickly than *kang* and ranks high as an emergency fodder suitable for the hot weather. Authorities in Russia, where it is extensively grown, consider that the best results cannot be obtained with it except at a temperature between 66° and 71° F. and that below 64° F. the growth is delayed by from five to ten days. Heads are usually formed, under the best conditions, from thirty-five to forty days after sprouting

An attempt has been made at Nadiad to see the extent to which it is likely to be useful as a fodder crop in Northern Gujarat in the early part of the cold weather. Seed was sown at various dates from August to December and the results with various particulars regarding the crop, are shown in the following table †:—

Date of sowing.	Yield of dry fodder.	Length of time growing.	Cost of crop.	Number of irrigations required.
1912	lbs.	days.	Rs. a. p.	
October 15	2,672	53	84 0 0	3
November 1	2,240	51	44 0 0	3
November 15	3,440	63	55 8 0	5
December 1	2,848	75	51 0 0	5
December 15	3,600	91	48 8 0	3

\* Kalkar in Leaflet No. 5 of 1911, Department of Agriculture, Bombay.

† Report of the Nadiad Agricultural Station, 1912-13. Results for planting for every month from August to April are given in the Report of the Nadiad Agricultural Station for 1913-14, but the yields are so small that I cannot think they are normal.

The average of these five lots gives a yield of 2,960 lbs. of air-dried *cheno* fodder, obtained in sixty days at a cost of Rs. 46-8-0 per acre. This is evidently a lower yield at this time of the year than is given by *kang* but the crop grows much more quickly, requiring sixty-six days as against eighty-one in the other case. It is doubtful whether it ought to be recommended until all fear of frost is over.

As a fodder it is not so desirable as *kang* being more woody and less leafy than the latter.

#### OTHER MILLET CROPS.

There are no other annual millet crops which are actually cultivated primarily as fodder in Western India to more than an extremely small extent, nor have experiments been made to a large enough extent to justify any considerable recommendation on the subject. Several others have, however, been mentioned, and occasionally used, and the notes which are available on the subject may perhaps be quoted here.

*Nachani* (*nagli, ragi, mukra*) or *Eleusine coracana* is, as a grain crop, the most important of the small inferior millets of India, and is grown for the production of seed in light soil, usually in tracts with heavy rainfall, all over Western and Southern India. Grown for grain, it is usually a transplanted crop, and this system of cultivation is, of course, far too expensive for a fodder crop. For the latter purpose, it should be sown broadcast or in drills at the beginning of the rains, in light soil with fairly heavy rainfall.

It has been considered as making a good fodder for cattle, and can be siloed or used as a green fodder when the seed is approaching maturity.\* On the other hand Mollison † states that the straw is thick and very tough near the root, so much so that it is not easily reaped with a sickle. He considers that the straw from the ripened grain is of very poor nutritive value as fodder and is hardly worth the cost of careful reaping. This is, however by no means universally accepted and it is valued highly in the Ratnagiri district. If the ripened plant is stacked for some months its fodder value is considered to have improved.

In America it has succeeded in small tests as a fodder crop in the Southern United States, but has nevertheless, never come into use. It does not apparently possess features of special value for this purpose.

*Sawan* (*Panicum frumentaceum*) and *Banti* (*Panicum crus-galli*) are so closely similar as fodder crops, though well distinguished otherwise, that they may be considered together. They are termed barnyard millets in America. There, attempts have been made from time to time to boom them as fodder crops, as the name "billion dollar grass" sometimes applied to the former of these millets indicates. For this purpose in India they have, however, been little used, though they are natives of this country.

The experience on the Government grass farms is, however, that when sown in the monsoon at the rate of about twelve pounds per acre, and cut in August, this crop makes excellent fodder, especially for milch cattle, and can be either used at that time as green fodder or converted into silage.\* In Sind, *sawan* has been found to be a useful fodder crop for the hot weather. At Mirpurkhas, for instance, "during the year a steady supply

\* Meagher and Williams—Farm Manual.

† Mollison—Text-book of Indian Agriculture, Vol. III, pages 58 and 60.

of green fodder was kept up on the farm, in the hot weather with *jowar*, *choula*,\* &c., and *sawan*, and in the cold weather with berseem. The *jowar* can be ready for fodder in May, and with *choula* \* and *sawan*, which form good change feeding, can be cut and fed till November, when berseem should be ready." † These notes indicate the conditions under which it is likely to be of service, and its method of culture.

In Northern Gujarat, experiments have been made with *banti* to ascertain the best time for sowing the crop for fodder. Seed was sown in every month from September to April, and its superior value in the hot weather was made quite clear. The results in 1913-14 were as follows:—

Date of sowing.	Yield of dry fodder.	Period of growing.	Number of irrigations.
1913-14	lbs.	days.	
September 15	2,400	54	5
October 16	3,400	82	6
November 15	1,200	87	6
December 15	1,120	103	8
January 15	640	72	6
February 15	4,800	89	10
March 15	7,000	63	6
April 15	3,200	47	5

The highest yields are with the crop put out in February, March and April.

According to American experience it may yield as high as six tons of hay per acre, provided there is plenty of moisture and the land is good, but I doubt whether this yield has ever been obtained in India. It is not easy to convert into hay as it has decidedly thick stems. It has been found good for silage, but is probably best used for feeding green. ‡ Here, however, except in Sind it is usually ready when green forage is abundant, and its chief use would probably be for putting in the silo. It has been used, according to Means, for the reclamation of salt and alkali land in Egypt.

If we summarise the position as fodder crops which the various millets—*bajri*, *kang*, *cheno*, *nachani*, *sawan*, &c.—are likely to take as fodder crops, we must first say that we look upon it as a minor one. They have the advantage in many cases of giving a crop very quickly, particularly in the hot weather, provided they have plenty of water—and this is their chief advantage especially in a famine season or where the monsoon is very short. When a matter of two, three, or even four weeks is not a matter of importance, they

\* Choula=chavli. See under the latter crop, page 117.

† Henderson—Mirpurkhas Farm Report, 1909-10.

‡ Piper—Forage Plants.

would seem to possess no advantages, at any season of the year,—except as a change feed in a country where there is no grass—over one or two of the varieties of *jowar* or over maize. In Sind—a country without natural grass,—some of them seem to form a good change feed with *jowar*.

Apart from these special uses, they seem to have no great utility as fodder crops, and though they will always be grown in light soils, yet they are not likely to attain a very important position in Western India for the purpose we are considering.

## VI. OATS.

I do not think that oats have been grown to an appreciable extent in Western India as a fodder crop outside the military grass farms where fodder is produced for military horses, but on these, at Ahmednagar and elsewhere, oats have proved themselves a very useful fodder. They can be grown best in the cold weather and always under irrigation. In Northern India this crop has probably a considerable future; in Western India its advantages are doubtful, though as a fodder for horses it provides better material than can be obtained in almost any other way. Cut and made into hay when the grain begins to fill or is nearly filled, it is known as "oats in straw," and, as Mollison notes, it is the chief fodder used for horses on board ship when being imported from Australia.

The use of oats as a fodder crop in India has been fairly well dealt with by Meagher and Williams,\* and I am not aware of other data on the subject. I, therefore, quote the substance of their account.

"This is excellent fodder for all animals, especially horses. It is sown for harvesting green in the same manner as if sown for the barley crop, *i.e.*, about 100 lbs. seed per acre. A rich moist soil is required for this crop. Attempts have been made to sow imported seed, such as Australian and Cape, but the former, though producing a large outturn of green fodder, has been found in this country to produce very little grain. The Cape seed has proved more successful, but on the whole, the best results have been obtained from selected country oats. The seed is sown about October, and is usually ready for harvesting as green fodder in February, or as oat hay by the beginning of March, while if kept for grain it should be ready for the sickle about the middle of March. It is advisable, however, to harvest the grain in the ear as is universally done in Australia. When the land is very rich and moist, or can be irrigated, it is possible to obtain two cuttings. In this case, the first cutting should be taken when the crop is two feet high and before the flower has formed. The second cutting should take place when the grain is approaching maturity, *viz.*, when it is soft and milky. At this stage, the fodder will be at its best, and there will be no risk of losing the seed during the harvesting or when stacked, which would be the case if the crop were more mature. On the other hand, if harvested too soon, the fodder will be succulent, there will be but little nutriment in the grain. The crop should be cut either by the mowing machine or by hand labour. Whatever implement is used, care should be taken that it is sharp as otherwise, a portion of the crop is uprooted instead of cut, and the earth adhering to the roots detracts from the value of the fodder. When cut it should be allowed to lie on the ground, and after a few hours' exposure to the sun, carefully turned and the process repeated several times. If cut early in the day, the fodder should by the evening be sufficiently dry for

\* Farm Manual.

cocking. It must be handled as little as possible, or the grain will leave the ear. It should remain in the cocks for about six days, and then be carefully stacked. Prior to issue, the whole, including the grain, should be passed through a chaffcutter."

There is little to add to this account. The yield obtainable is indicated by the fact that at Poona, in 1896, oats yielded 5,146 lbs. per acre green, while in 1908, a crop of 8,400 pounds per acre of green fodder was obtained. Oats as a fodder crop have a special position, and as a fodder for horses, grown in the cold weather and easily capable of being converted into hay, the crop has hardly at present a rival.

## VII. GUINEA GRASS.

A very special place among fodder grass crops must be given in Western India to guinea grass. This has proved itself of extreme value as supplying a good succulent nutritious fodder throughout the year, and its use is spreading rapidly. The peculiar advantage of this grass is that it grows well under shade, and especially so under mango trees, while a small daily supply of good green feed can be obtained without any cost by planting it on the sides of permanent water channels.\*

Guinea grass (*Panicum maximum* or *Panicum jumentorum*) is a native of tropical Africa, but its cultivation has been recommended in India since 1793. The general character of the plant is well described by Mollison as follows:—"This perennial grass grows in tufts or tussocks, many stems springing from one root. The roots are fibrous, and form a network in the soil near the surface. In countries of moderately temperate climate such as that of the plains of Northern India, the grass remains more or less dormant in the cold weather, but flushes up again with warmth and moisture afterwards. In the hotter part of India the grass remains green throughout the year under irrigation. It may even exist without irrigation in the fair season. Such plants as survive spring up into vigorous growth when the rains come. In the monsoon and sometimes at other seasons the grass flowers and produces seed freely in India. When in full flower, the stalks are five to eight feet high, and the graceful branching panicles give the crop a very handsome appearance. During the greater part of the year, leaves are produced rather than flower stalks. The best results are obtained with copious irrigation throughout the year and with heavy applications of manure. In the warmer parts of India guinea grass grows best in the monsoon and the early part of the cold weather. It has no dead season, but gives a decidedly poorer outturn in the fair season than in the monsoon."

### *Climate required by Guinea Grass.*

The conditions under which guinea grass grows successfully seem exceedingly varied. It has been recommended and grown in almost every part of India. Outside of India it has been found valuable in nearly every tropical country, whether wet or dry. In the Philippine Islands it has given extraordinary yields;† in the wetter regions of the United States it has been

\* See Leaflet No. 22 of 1909 of the Bombay Agricultural Department.

† 32 tons of green fodder per acre in four cuttings. Jacobson—Philippine Agricultural Review, Vol. VII (1914).

successful\* and also in the drier regions of Texas.† It seems as if it will go on growing as long as the temperature is sufficiently high, and sufficient moisture is provided. As Mollison remarks (*vide supra*) in the more temperate parts of India it ceases to yield in the cold weather, though the temperature never goes below 40° to 45° F. Even at Surat, with a minimum temperature five degrees higher, its cultivation was abandoned in 1906-07, as the yield outside the monsoon season was very small, and a better fodder return was thought to be obtained by growing *jowar* in the monsoon.‡ Though the abandonment there seems hardly justified, it illustrates how the yield of the plant drops when the temperature falls, in spite of irrigation.

All over Western India irrigation is required if the crop is to be grown economically and commercially. If not irrigated, it does not possess sufficient advantage for its cultivation to be recommended. In the United Provinces it has been stated not to require much water on account of its deep rooting habit.§ Our experience in Western India is, however, that it can hardly have too much.

At present its cultivation in Bombay is steadily growing. The demand on Poona for root stocks as seed is continuous, and considerable, and though its area is not separately measured or recorded, yet it is grown in every part of the Bombay Presidency, including Sind, except in the Konkan. Even in the Konkan it has been recently introduced and grows luxuriantly,¶ though sufficient evidence has not been accumulated for us to know how it will stand continuous growth there.

#### *Soils.*

Guinea grass will grow in almost any soil, provided it is not water logged. It does best perhaps on medium loam which can be irrigated to advantage, or on light deep sandy soil.|| It may even be grown with advantage on land treated with town sweepings or even with nightsoil, if only it is kept free from weeds and the top surface kept soft.\*\*

#### *Cultivation, Planting and Treatment.††*

The soil should be friable down to a considerable depth, and this condition can be obtained by two ploughings, three or four harrowings and clod crushing if necessary. Thirty cartloads of farm yard manure should be worked into the soil during the tillage.||

\* Scott—Florida Agricultural Experiment Station Report, 1912.

† Hastings—U. S. Bureau of Plant Industry, Circular No. 106 (1913).

‡ Surat Agricultural Station Report, 1906-07.

§ United Provinces Agricultural Department—Bulletin No. 6 (1897).

¶ Ratnagiri Agricultural Station Report, 1913-14.

|| Mollison—*loc. cit.*

\*\* Meagher and Williams—Farm Manual.

†† We owe practically all the details of cultivation to Mollison. No better methods have been evolved since his time.

The grass is propagated by seed or by division of the tussocks. The latter method is almost invariably used, and five or six root bearing stems should be planted in one place. The groups of sets should be eighteen to twenty-four inches apart in each direction and the lines should be laid straight both lengthwise and across, so that interculturing may be done easily. This planting should be done on flat ground in the rains. June and July are the best months in Western India\*, wherever the monsoon rains occur. If the planting takes place at any other season, the field should be flooded with irrigation water immediately after planting. In the monsoon, the sets can be planted during rain on light land, and soon after rain on heavier soil. When the plants have taken root, they should be ridged up (they remaining on the ridges) so that irrigation water may flow among the furrows.

If guinea grass is grown from seed, the seed should be thinly broadcasted in a well prepared seed bed. When the seedlings are well grown and have each produced three or four shoots, they should be transplanted into rows in the manner already described (Mollison).

After a plantation has been established, "guinea grass can hardly get too much water or manure.\*" The richer the land, the more succulent and tender will the fodder be.† Each year at least fifteen cartloads (12,000 pounds) of farmyard manure per acre should be applied before the rains‡, or well rotted manure should be given in dressings of at least five tons per acre every fourth time the grass is cut. Few experiments in other forms of manure except with farmyard manure seem to have been made, but it has been found that guinea grass responds very quickly to well selected artificial manures, even more than to organic manures like oilcake or dried blood. In an experiment in Florida, it was found that guinea grass manured with a mixture of nitrate of soda, superphosphate, and potash manure gave a yield of 3,370 pounds of cured dry hay per acre, while a similar plot manured with dried blood only gave 2,341 pounds similarly cured§.

If guinea grass be grown under sewage or sewage effluent very high and sometimes extraordinary yields may be obtained. At Poona, with septic tank effluent in 1899-1900, 56,308 pounds of green fodder per acre were grown. At Karachi, under raw sewage, eight cuttings have been secured per annum with 25,000 to 30,000 pounds of green fodder per cutting, or over 200,000 pounds per annum¶.

On the other hand without manure its yield rapidly declines. In Surat it has been stated that only when guinea grass obtained much manure it gave good yields: when put in fields without manure it only gave half yields||, and less than is given by a single rains crop of *jowar* fodder. The necessity of continuous and heavy manuring could not be better illustrated.

If the rainfall be normal, the crop will not require irrigation in the monsoon over the greater part of Western India, except in Sind. But as soon as the rains are over, it should be irrigated every ten or twelve days throughout the year.

\* Mollison—*loc. cit.*

† Meagher & Williams—*loc. cit.*

‡ Leaflet No. 22 of 1909 of the Bombay Agricultural Department.

§ Florida Agricultural Experiment Station Report, 1911.

¶ Kalkar—Bulletin No. 34 (1909), Bombay Agricultural Department.

|| Surat Agricultural Experiment Station Report, 1906-07.



Guinea grass is very apt to become over-run with weeds, and hence fairly frequent weeding is necessary. In ordinary practice here, this has usually been done by running a country plough or a country bullock hoe between the rows in both directions, and completing the operation by hand weeding where the bullock implement cannot reach. The country bullock hoe can probably hardly be improved for this purpose.

Though the grass is perennial the plantation is not and, if not dug up and replanted frequently its yield will rapidly decline, and it is usually necessary to re-establish it after three years. The same land can usually be used again, but the tussocks of grass become over-grown and form big stumps with many dead shoots in them. The roots become thickly matted together, and digging out is essential. The way this replanting should be carried out is as follows. New sets should in the first instance be chopped off the old tussocks and planted in the furrows at the required distance apart, and when these are established the old tussocks should be removed. This makes it possible for the new plants to be almost in full vigour before the old ones are taken away.

One method of planting, which has been already referred to, is that along the sides of irrigation channels. Here the guinea grass serves a very useful and profitable purpose. It is the usual custom to leave the sides of irrigation channels to the care of nature. Abundance of weeds and grasses grow along them, and sometimes even spread into the channels and partially block them. Moreover many weed seeds are scattered on the irrigated land adjoining. If, however, guinea grass sets are planted in this position, the sets being placed twenty-four inches apart, the grass grows very well indeed and smothers the weeds, besides protecting the sides of the channels from erosion. It also produces a considerable amount of good fodder from an area usually almost entirely wasted. The amount of profit thus obtained is indicated by experience on the Agricultural College Farm, Poona, in 1913-14, where from 2,596 feet of water channels, with guinea grass on both sides, 9,272 pounds of green guinea grass fodder were produced, which at 150 pounds per rupee was worth Rs. 62.\* This is obtained without any special expenditure and the fodder is available in some quantity throughout the year.

The crop has so far, in Western India, been free from disease, and the remark of Mollison to this effect can be confirmed after fourteen years' further experience. Smut occasionally attacks the ears, but when the plant is grown for fodder this is not a matter of importance.

#### *Reaping the Crop.*

The first cutting of guinea grass can be obtained in three months after planting the sets. When first cut it should be three or four feet high as if it is allowed to grow more than this, it becomes very coarse. This is also the case when the flower stalks are allowed to form. The leaves and stalks under these conditions become very fibrous and are not liked either by cattle or horses.

Subsequent crops should be cut at a height of two to three feet, as the oftener it is cut, the finer will be the fodder, and the larger the outturn. In Poona it is the custom to take cuttings about every six or seven weeks when the plantation is established, or about nine or ten in a year, but in some parts of India, as many as twelve cuttings have been obtained annually.

\* Agricultural College Farm Report, Poona, 1913-14.

In reaping guinea grass it is very important to cut it as close to the ground as possible. If this is not done the stubble remains as dead matter in the grass tuft, and prevents the further cutting of the grass as low as might be desired, as well as tends to check the growth.

*Yield of the crop.*—The yield of guinea grass obtainable seems to vary very much, but the highest on record seem to have been obtained under sewage at Karachi as already stated, namely, over 2,00,000 pounds (green) per annum. Apart from this the highest on record are in Northern India. Meagher and Williams state that they have obtained 1,500 maunds or 1,20,000 pounds (53½ tons) of green fodder per acre in twelve cuttings.\* This is an extraordinary amount and far in excess of any other record I have seen except that quoted from Karachi. Thirty-two tons per acre have however, been obtained in the Philippines, and this in four cuttings†. Under ordinary circumstances in India, however, it yields between thirty and forty thousand pounds of green fodder per acre as a maximum and the yield of a plantation even when renewed frequently tends to fall to half this amount. At Pusa‡ in 1911-12 the maximum yield quoted was 28,700 pounds per acre.

In Bombay the yield has been exceedingly variable. Mollison considers from 20,000 to 35,000 pounds per acre as normal yields with eight cuttings but the actual records from various centres in Western India are as follows:—

## POONA.

Year.	Yield per acre.	Cost per acre.	Value of crop per acre.	Number of cuttings.
	lbs.	Rs.	Rs.	
1893	35,028	110§	233	10
1894	21,295	82	106	10
1896	19,167	49	96	No record.
1897	16,106	73§	80	"
1898	15,493	53	77	"
1899	13,552	67	68	"
1900	17,103	61	114	"
1902	13,662	60	91	"
1903	12,252	No record.	(Profit Rs. 46)	"
1904	12,551	49	84	4
1905	12,569	34	89	"
1906	15,566	42	78	"

\* Farm Manual.

† Jacobson—Philippine Agricultural Review, Vol. VII (1914).

‡ Milligan—Report, Imperial Agriculturist, 1911-12.

§ The extra cost in these years is due to manuring being done in these years only, in the years before 1900.

These records of yield in Poona tell of the very large yields which may be obtained. They tell also how essential it is for a plantation to get full attention and to be fully renewed. In the present instance this renewal was not attended to, for in 1904 it was noted that "the plantation is old and needs renewal." The result was a decline in yield, and a reduction in the number of cuttings. During the years from 1893 to 1900 the average yield was 19,700 pounds or 8.8 tons of green fodder per acre—equivalent to slightly under four tons of dry fodder per acre. The average annual yield is thus a little below what would be expected for a single crop of *sundhia* fodder, though, of course, the crops cannot be compared purely on a basis of yield. In the following years (1902-1905) when the plantation was confessedly old and needed renewal, the average yield was only 12,750 or 5½ tons of green fodder, equivalent to 2½ tons of dry fodder per acre. The yield of an old plantation may go down as low as 4,100 pounds of green fodder per acre. The urgent necessity of the frequent renewal of a guinea grass plantation could not be better illustrated than by these figures, especially as they are confirmed by experience at Surat to be given later.

When a guinea grass plantation is commenced at the beginning of June, the yield in the first year is small, that at Poona, for instance, in 1906-07 yielding 4,323 pounds of green fodder per acre before the following March.\*

## SURAT.

At Surat, on somewhat deep black soil, and with a rather brackish irrigation water our experience has not been as long as at Poona, but the results are as follows:—

Year.	Yield per acre.	Cost per acre.	Value per acre.
	lbs.	Rs.	Rs.
1898-99	28,580	172	190
1899-1900	29,549	116	197
1900-01	42,594	170	213
1901-02	22,302	No record.	114
1902-03	29,341	175	147
1903-04	25,885	176	172
1904-05	13,972	167	93
1905-06	13,613	194	124
1906-07	13,484	113	90

Here, we get a clear illustration of the deterioration of a plantation which does not receive frequent renewal and full quantities of manure. In 1903 the plantation was reported to be choked with dry stumps, and thereafter it deteriorated rapidly, till in 1907 it was abandoned as unprofitable.

It was however planted again in 1912, and yielded, in heavy soil, 17,274 and 15,869 pounds per acre of green fodder in two successive years.

\* Poona Dairy Farm Report, 1908-09.

Experience elsewhere in Western India where records are obtainable has been shorter, but may be indicated as a guide in the various districts. At Dhulia\* (West Khandesh) guinea grass planted under trees gave 11,000 pounds of green fodder per acre in the year of planting—an exceedingly good result—and 30,620 pounds in the following year. This is in one of the typical black soil districts of the Deccan.

On light sandy land at Gokak† it was equally successful, and gave six cuttings in the first year and the same number in the second. This took place in spite of the land being somewhat salt (*karal*), and the soil having to be mixed with nala-silt before it would grow any crop. At Ratnagiri‡, as already stated, where the rainfall is much heavier, it has been exceedingly luxuriant during the last two years, though it is still a question whether it will stand the heavy rainfall of the monsoon there. In Sind§ it is very successful indeed.

As far as our experience goes, in fact, there seems no part of Western India in which guinea grass will not grow and grow luxuriantly, and for its own purposes, it is one of our most valuable fodder resources.

#### Feeding Value.

Except when allowed to go to seed, guinea grass makes an exceedingly valuable and nutritious fodder. Analyses by Leather¶ have given the following results. The first two samples given were obtained from Poona and analysed in the fresh condition: the third is an average of many examinations of the dried grass, and the analysis is given on a basis of ten per cent. of water.

	1 Fresh grass (Poona).	2 Fresh grass (Poona).	3 Dried grass (Average).
	p. c.	p. c.	p. c.
Water	63.4	71.5	10.0
Ether Extract (oil, &c.)	0.8	1.0	2.6
‡ Albuminoids (Proteid nitrogen $\times 6\frac{1}{2}$ )	1.9	2.6	6.2
Soluble Carbohydrates	19.4	13.7	45.8
Fibre	8.8	5.7	20.1
Ash	5.2	5.3	15.4
Total	100.00	100.00	100.00
Total nitrogen	0.41	.53	1.3
Proteid nitrogen	0.30	.42	1.0

\* Report, Dhulia Agricultural Station, 1912-13.

† Report, Gokak Agricultural Station, 1912-13 and 1913-14.

‡ Report, Ratnagiri Agricultural Station, 1913-14.

§ Report, Mirpurkhas Agricultural Station, 1913-14.

¶ Leather. Agricultural Ledger No. 10 of 1901 and No. 7 of 1903.

It is thus an exceedingly fine fodder for all descriptions of farm animals, and experience in Western India has confirmed the result of analysis. For horses it has been used for many years on the military grass farms and remount depots. "At the remount farm, Ahmednagar, the young horse stock are regularly fed with it. The daily ration increases with age, twenty-five pounds chaffed with dry food being the daily allowance."\* It is very much liked by horses of all ages. For dairy cattle it is equally good, † and has been fed to them for many years at Poona with success. The same has been the case elsewhere, and in Porto Rico it is stated that "it is the best adapted as a pasture for cows, the fat content averaging considerably higher for cows so fed."‡ It can be fed up to forty pounds per day per head to dairy cattle with advantage.\* For working cattle it is regularly used in many parts of the country, and at Saidapet it was used for ewes and lambs with success.

In India the crop has been hitherto almost entirely cut and fed green. At Saidapet a well established plantation was however grazed with success, and abroad this is often done. † But it must not be grazed too closely, or it will not recover quickly. The principal advantage as a fodder is that it secures a supply of green fodder during the dry parts of the year from areas which would otherwise be largely waste (such as places under shade, or the banks of irrigation channels), and at this time the green soiling system is by far the most applicable.

During the rains, however, when there is abundance of green fodder, and when it grows luxuriantly it can be used to make very good silage, and for this purpose it is as good as any grass we have. After the rains are over, say from the third or fourth cutting from the commencement of the season in June, it can be made into fairly good hay without any difficulty, provided the weather is favourable. As the season proceeds, there is less and less danger of any difficulty through rain, and several crops of hay may easily be obtained if the grass is not needed as green fodder.

### VIII. OTHER GRAMINEOUS FODDER CROPS.

The crops so far dealt with,—the various types of *jowar*, maize, the millets, and others, represent either the best gramineous annual fodder crops in Western India, for general use, which are known at present, or crops like guinea grass which have a certain definite position in the economic fodder supply of the country. There are a number of others which are or have been grown specifically as fodder crops. Some of these have advantages under special circumstances, either of soil, of climate, or of adaptability to special circumstances: others have been introduced in the hope of their filling a need, and have proved a failure: others again are only in the first stage of experimental introduction. We will review these, and indicate such of them as appear to suit various conditions or circumstances.

#### TEOSINTE.

A grass of which much has been expected and which under favourable circumstances yields a large amount of fodder is teosinte—*Euchloena*

\* Mollison—*loc. cit.*

† "For young horse stock and dairy cattle it cannot be surpassed" (Mollison).

‡ Lucas—*Journal, Indust. and Engin. Chem.*, Vol. VI (1914).

*mexicana* or *Beana luxurians*. This is a coarse annual grass, growing from eight to twelve feet high, with many stems originating from one root. It originates probably from Central America. It is essentially a tropical grass, and the least frost spoils it entirely. The large crops which it gives on rich soil and the fact that cattle eat it freely has made it one of the plants most frequently experimented with as a fodder crop. Piper<sup>o</sup> quotes yields of green fodder which have been obtained in various parts of the United States which vary from nine tons per acre in New Jersey to fifty tons in Louisiana. In spite of all this, its cultivation is decreasing in America, and this is suggested by Piper to be due to the fact that it needs rich soils, that on soils of moderate fertility it does not yield as well as sorghum (*jowar*), and that the seed cost is high.

Experience elsewhere seems to indicate that it has ultimately only really proved successful in damp, warm regions of high humidity, and large rainfall. In the West Indies (Dominica) † it gave, for example, twelve tons of green fodder per acre, and is considered as suitable for poor sandy soil there. In the Philippines it has given as much as 27.67 tons of green fodder per acre in 141 days. ‡ I have myself seen it yield very high returns of green fodder in the Assam Valley. But in drier climates, with less rainfall, even when irrigation is available, it has been a disappointment. In Rhodesia § it is considered as "not satisfactory." In Arizona || it is not a success in dry farming, and so on. Its water requirements, per pound of dry matter produced, are, however, only slightly higher than those of maize. ¶

Experiments in Western India fully confirm this position. Teosinte was at one time considered as very promising and gave when grown in Poona as a rains crop, the following yields in several years following 1893 :—

Year.	Yield <sup>o</sup> dry fodder per acre.**	Cost per acre.	Value per acre.††
	lbs.	Rs. s. p.	Rs. s. p.
1893	9,444	54 0 0	85 0 0
1894	15,204	28 0 0	115 0 0
1895	6,690	18 0 0	87 0 0
1896	2,208	12 0 0	22 0 0 ††

• Forage Plants, page 304.

† Dominica Botanical Station Report, 1908-09.

‡ Philippine Agricultural Review, Vol. II (1909), page 24.

§ Hampton—Rhodesia Agricultural Journal, Vol. VIII (1911).

|| Arizona Agricultural Experiment Station Report, 1912.

¶ Briggs and Shantz—Journal, Agricultural Research, Vol. III (1914).

\*\* 2½ pounds of green fodder are taken as giving 1 part of dry fodder.

†† Teosinte fodder at first commanded the same price on the market as *milwa*; after 1895 it was priced 20 per cent. cheaper.

‡‡ On light land.

These yields might be considered to be at least fair, giving (even including 1896 on light land) an average crop of  $5\frac{1}{2}$  tons of dry fodder to the acre. But during the time when the experiments were going on other unfavourable characters of the crop as a fodder had presented themselves, so much so that in 1896 Mollison\* stated that the crop "may be dismissed as of no economic value in the Deccan." In this connection, it may be well to reproduce the remarks made after each year that he was growing the crop by this high authority, as they illustrate the fact that his opinion was getting steadily worse.

After the 1893 season Mollison remarked "The stalks are tall but coarse and fibrous. The leaves are also coarse, but are liked by cattle. The plant tillers freely. The seed should be sown by dropping it by hand into every second furrow made by a plough: the plough, in making the next furrow, covers the seed. Five pounds of seed per acre are sufficient." "The seedlings should be singled to fifteen inches apart. On heavily manured land the crop is ready to cut in 85 days. If a long stubble is left, *Reana* shoots up vigorously a second time, and yields a second cut in seven weeks. Subsequently the shoots are less vigorous, and the crop fails to produce profitable cuts." In the following year it was noted that the crop was sown on June 30th, thinned on July 20th, cut at the end of September, and again a small cut was obtained at the end of October, and the following remarks were made "It grew slowly and had to be handweeded: after singling it grew rapidly. If the seed is dibbled, two to four pounds per acre will be enough. It took three months to flower, while other fodder flowered in 48 days. It has very great root development, and appeared an exhausting crop." After 1895 Mollison simply noted that it was very coarse. It germinated very unevenly, but improved much during heavy rain in October. In the following year the vagaries of the crop, the coarseness of the fodder, and the slowness of its growth as compared with other available fodders led Mollison, as already stated, to dismiss it as of no economic value in the Deccan.

Attempts have recently been made at Poona to see whether this opinion of Mollison was really justified. The results have led to the same conclusion, and the additional objection has been noted that "milk cattle drop in the milk yield when this fodder is substituted for maize." † Thus from every point of view, as a fodder crop in Western India teosinta is to be condemned. It yields less freely than *jowar* and maize—and the crop is obtained more slowly and is a coarser fodder. Its fodder is liable to influence the milk yield of cows,—and beyond this it is a somewhat doubtful crop. This is in Western India: nothing of this necessarily applied to teosinte as a fodder crop in a moist warm, rainy locality, where indeed it may be very valuable.

If grown in Western India, however, the method suggested by Mollison is probably the best. The seed should either be sown in the alternate plough furrows, and the resulting crop thinned after a month, using from ten to fifteen pounds of seed per acre,—or it should be dibbled in rows at fifteen inches apart both in the rows and between the plants when only three to four pounds of seed per acre will be needed. Piper recommends planting in hills four to five feet apart, or in rows at the same distance. It should be irrigated, if necessary, and will not stand drought. If grown as a monsoon crop it will be ready to cut three months after seeding, and a second crop can be obtained (usually with irrigation) from four to seven weeks later. It is not worth while keeping it for the small third and fourth crops which it will yield.

\* Poona Farm Reports, 1893 to 1896.

† Poona Agricultural College Farm Report, 1913-14.

The fodder is coarse, and in my experience, has always been fed green. It has never here been made into either hay or silage. I have never analysed a sample of the fodder, but in Australia the following figures have been obtained for the green crop completely dried.\*

Ether extract (oil, &c.)	...	1.39
Proteids	...	7.27
Digestible fibre	...	42.55
Nitrogen-free extract	...	11.20
Woody fibre	...	27.67
Ash	...	7.03

Its nutritive value was found to be about 83 per cent. of that of sorghum (*jowar*) fodder.

#### ANDEPOGON HALEPENSIS. †

This crop, also known as *Sorghum halepense*, in America as Johnson grass, and in Northern India as *baru*, is really a native of Southern Asia, and possibly of India. It is so like *jowar* that it has been taken by many to be a perennial variety of that crop, and they have considered that *jowar* had possibly been derived from it under cultivation. The latest opinion, however, is that the two must be regarded as distinct species, ‡ but the very fact that the discussion has arisen shows how very similar this plant is to our ordinary cultivated *jowar*.

In the early days of agricultural experiment in Bombay, the plant was introduced as a promising fodder crop, and at first seemed likely to be very useful. At once, the advantage of its being a perennial, giving a series of cuttings, without any sowing, was realised,—and as the yield in the first year was very good, it seemed that it was likely to have a future in Western India. It was introduced into Poona from the military grass farm at Allahabad, was sown in July, and cut in August, yielding 4,720 pounds of green fodder per acre in one cut. It was noted as growing vigorously in the early monsoon in Poona. In the following year it grew well so long as the rain continued, but a drought in August and September completely stopped its growth,—while a plague of rats found the underground perennial stems a favourite food.

In 1898 the results found everywhere where this plant has been cultivated as a fodder crop began to be apparent. It tended to form a matted mass of underground roots, and once these were formed further growth almost entirely ceased, and the grass ceased to flourish. It was hence necessary at this stage to take it out and replant—but when the attempt was

\* See Agricultural Gazette of New South Wales, Vol. XXI (1910), page 118.

† There has been a good deal of confusion about the name applied to this grass. In some Indian publications, and in some from the West Indies also, it is called "Sudan grass." Now this latter name is used in the United States (where the name was first used) for an annual grass which is very different in all its cultural characters, and with which I shall deal below (see page 78). I think it will be wise not to use the name "Sudan grass," for *Andropogon halepensis* any more here. It is certain to cause confusion and if the vernacular name *baru* or the American name "Johnson grass" is applied, there can be no question as to what is meant. I shall do this in the present article.

‡ Piper—Proceedings of the Biological Society, Washington, Vol. XXVIII, p. 25 (1915).



made to do so, it was found to be very costly to get rid of in order that it might be replanted. If this had to be done so soon in the life of the grass, too, its advantages largely disappeared,—as bigger yields of fodder could be obtained from other crops.

By 1900, its eradication rather than its cultivation had become the question, and it was noted as being as difficult to get rid of as *kunda* (*Saccharum spontaneum*) one of the terrors of the Deccan cultivator in arable land. It had ceased to yield heavy crops,—and it could hardly be got rid of.\* By the following year it had been cleared out, and on the Poona farm, there has been no question of planting it again since. Mollison (1901) does not mention it as a fodder crop for Western India at all. †

While this is our experience in Western India, it is fair to note that the military grass farms have maintained the crop in various parts of the country, and speak highly of it as a fodder for horses, and state that it continues to give good yields. Cultivated as they grow it, it is rather, however, in the nature of a meadow grass than a fodder crop properly so called. It is, however, being recommended in the military dairy farms at the present moment for the special purpose of giving a permanent fodder supply on irregular ground such as the banks of river, or tanks or similar places, where an annual crop is almost out of the question. In these places it yields well, at any rate at first, and gives good fodder.

Experience in the United States has been very similar to ours. Piper ‡ writes as follows. "The plant can scarcely be called a cultivated grass, as when once planted it is difficult to eradicate and therefore it is rarely grown intentionally. Indeed, in regions where it does not occur, great care is taken to keep it out. Where, however, it is established, it is abundantly utilised both for hay and for pasture. On good soil two crops and sometimes three may be cut in one season. It quickly becomes "sod-bound," and unless ploughed up every year, or at least every two years, the yield becomes very small."

One objection to the use of this grass for feeding is the fact that, like *jowar*, it seems to be poisonous in its early stages, especially when vigorously growing plants are stunted by drought or otherwise. The matter seems never to have been closely investigated in this case, but both in India and America occasional reports have been made of injury from this cause. Duthie says that in Northern India various reports indicate its injurious effects on cattle if eaten when too young or when the plants are stunted by drought. §

I do not think that as a fodder crop in the ordinary sense, this grass has much future—or many advantages over other plants, except under the special conditions already suggested. Even there it will require special methods of culture, and will need great care if it is not to spread and become a regular nuisance and an almost ineradicable pest over large areas.

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\* The question of the eradication of Johnson Grass has been a very serious problem in some parts of the United States, and is dealt with by Cates and Spillman in *Farmers' Bulletin No. 279* (1907). This is hardly the place to deal with its eradication, but I may note that they recommend close cutting or grazing in land infested with the grass, and after this has been done for a whole year, ploughing the land shallow, succeeded by intelligent and efficient cultivation.

† Text Book of Indian Agriculture, Vol. III.

‡ Forage Plants, page 245.

§ Fodder Grasses of Northern India (1888).

## PASPALUM DILATATUM.

One of the most extraordinary stories in the recent history of agriculture in India is the advocacy of *Paspalum dilatatum* or Golden Crown grass as a means of avoiding famine, and as a grass which would thrive under drought conditions when other grasses die. If the grass were all that has been claimed it would be an exceedingly valuable introduction to the drier parts of India. It is, as we shall see, a very valuable grass, but is in no way specially suited for resisting drought.

*Paspalum dilatatum* is a grass probably native to the southern part of the United States of America which was introduced from there into Australia by Mueller who did so much for the acclimatisation of valuable foreign plants in that country. This one was found particularly valuable in the northern parts of New South Wales. There, in a grazing region, it was found to thrive on poor soils, to give, if rain was adequate, a rapid and continuous growth, and to provide a very rich and succulent fodder. It was stated that "provided it can obtain enough moisture, it will grow anywhere", even on poor sandy land, and with fairly deep soils it was found to withstand a moderate amount of drought when well established as a perennial grass. The country where it is grown in New South Wales has not to undergo a really serious drought such as we have in Western India every year, except occasionally. When Australian and other writers speak of a drought resisting plant it must not be taken that what they say would mean in any sense that the plant would be able to endure the seven or eight months practically complete dryness with high temperature during a large portion of the time, which is the annual condition of things over the greater part of Western India.†

Grown under its own conditions *Paspalum dilatatum* is a very valuable grass. It grows to a height of five feet with numerous leaves half an inch in width. It is almost evergreen, being affected only by severe cold. Although its name suggests its growing in wet places, it flourishes in almost any kind of soil, and improves under grazing and trampling. It grows from seeds or root cuttings, and when established, it lasts indefinitely, while it is not difficult to control if a change of crop is desirable. Though it will stand a fair amount of drought when well-established on deep soils, it is perhaps more characterised by being able to stand much wet weather, as illustrated by its behaviour in Guam where it is stated to have done well on poorly drained soil during long periods of heavy rainfall.§

This grass had been introduced into India between 1890 and 1900 and had given good results in Tirhut, under conditions of soil and climate quite likely to suit it if it once became well established. In the anxiety result-

\* Fodder grasses of Northern India, 1888.

† See for example, Potts—New South Wales Farmers' Bulletin No. 8 (1909). Orange River Colony Annual Report, Agricultural Department, 1908-09. Mundy—Rhodesia Agricultural Journal, Vol. VIII (1910).

‡ As an example of the kind of climate to which Australian writers refer when speaking of drought resisting conditions, the following average rainfall for Richmond College are given, January 3.42 inches, February 2.65 inches, March 3.78 inches, April 2.55 inches, May 2.72 inches, June 2.61 inches, July 2.33 inches, August 1.89 inches, September 2.10 inches, October 2.20 inches, November 2.33 inches, December 2.89 inches. Total 30.18 inches. This would seem a very different climate with rain far more evenly distributed than any we have in Western India.

§ Thompson—Annual Report, Guam Agricultural Experiment Station, 1910.

ing from the terrible famine of 1899-1900, one of the most extensive and ruinous we have ever had, there was great enquiry for drought resisting fodders which would make the country largely independent of a partial if not of a complete failure of rain, and an article praising this grass as a drought resister in the "Melbourne Leader" (Victoria, Australia) was reprinting first in "Indian Gardening and Planting" (Calcutta) and then by the Government of India in the Agricultural Ledger.\* As a result enquiries were made from all over the parts of India liable to be affected with drought, a considerable amount of the seed was purchased at a high price and imported from Australia, and experiments were initiated with it on experimental farms and elsewhere.

It may be at once said that as a drought resisting fodder crop with us, it has totally failed. Where it has succeeded has been with irrigation or on good moisture-retaining soils with a rainfall above the average,† and under these conditions it has not shown itself possessed of qualities raising it seriously above some other fodder crops. It has however been felt that its use with us is as a drought resistant grass; if it has not this quality of drought resistance to the extent that we require, we have little more interest in it.

Our experience in Western India, where it has been grown experimentally at Poona‡ is what, perhaps, might have been expected. In 1902 when introduced it was found to grow well, to tiller splendidly, but to grow flat and not tall, and to suffer very much on the medium black soil of the Poona farm as soon as the long dry season became established. It was saved alive by irrigation, and it was hoped that the acclimatised seed might show better results than that originally imported. The next year the same result was repeated. The grass only survived by means of irrigation, and it only gave two small cuttings in the rainy season. The new seed was a disappointment also. It behaved exactly like the original, needed the same amount of irrigation, and the grass was totally ineffective as a drought resister. Similar experiments at Nadiad (Gujarat) on a deep light alluvial gave similar results.§ Two cuttings were obtained from the grass in 1903, but the grass needed watering, and, if not irrigated, it dried up early in November while the ordinary grasses of the country were still green. It has grown very well under regular sewage irrigation at Karachi giving 16,000 pounds of green fodder per cutting.

Under the conditions of Western India, nearly all of which has annually as already stated, six to seven months of practically complete drought, *Paspalum dilatatum* has proved of no service. It pays better to grow a large crop of fodder during the rainy season by growing maize, jowar or some similar crop and preserve this by making it into silage, and to supplement this by growing a highly irrigated grass like guinea grass in the dry season, rather than to grow a crop which likewise demands irrigation, but gives a considerably smaller yield of fodder than can be obtained in the way suggested.

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\* Agricultural Ledger (1901), No. 1.

† Central Provinces Bulletin No. 7, Agricultural Department (1902).

‡ Poona Farm Report, 1902 and 1903.

§ Nadiad Farm Report, 1903.

## MAURITIUS WATER GRASS OR PARA GRASS.

A very valuable perennial grass which serves very similar though not quite the same purpose as those served by guinea grass is Mauritius water grass or para grass (*Panicum muticum* or *Panicum molle* or *Panicum barbinode*). This, which has become the principal fodder grass of many parts of Ceylon, of Mauritius, and of many of the West Indies, grows very well at least in Poona, and its cultivation is worth considering for conditions for which it is particularly suited. It was introduced into Poona in 1894, and was planted on very damp, low lying, and somewhat waterlogged places in the Poona farm. It gave yields as follows:—

	Yields.
	lbs.
1894-95	... 50,020 in four cuttings.
1895-96	... 37,860 in three cuttings.
1896-97	... 27,690
1897-98	... 26,807
1898-99	... 26,377
1899-1900	... 24,528
1900-01	... 16,900*
1901 02	... 30,700

Thus the average yield for eight years, in a position where most good grasses will not flourish, was over 30,000 pounds or nearly 13½ tons of green fodder per annum. In spite of this very excellent yield, the grass has been allowed to die out, and if its cultivation is resumed sets will have to be reimported from Ceylon. This however is an easy matter, and the grass seems to be worth further trials in Western India under the conditions for which it is suitable.

The best account of its cultivation is that given by Tracy,† and this summarised is as follows. Para grass originally came from South America, whence it has spread to many tropical countries and has become a favourite fodder in the South United States. It is a rank growing perennial grass, spreading by surface runners, which are often thirty or more feet in length with roots at every joint. It is planted by division of these runners. A piece containing two or three joints is pushed down into freshly ploughed ground so as to leave the upper joint at or just below the surface. When sufficient of the seed runners are in hand, they should be planted about two feet apart, and as soon as these spread so as to cover the ground fairly well, the younger stems assume a more erect position and grow to from three to five feet high, giving a heavy yield of grass.

The condition suited to this grass is a damp situation, almost waterlogged. It grows well on the margins of ponds or tanks, or on the banks of ditches, often reaching out into the water, where the latter is even three or four feet deep. It is stated to be very suitable for land liable to be overflowed with water, as it is not killed when covered with water even for more than a month. Although it is said to make a fair growth on rather dry soil, it is essentially a crop for damp places, and in Western India, in any but these, it will undoubtedly need heavy irrigation. Apparently if its demand for water is satisfied, it will grow on any soil.

\* The yield this year is stated to have been small, owing to want of late rains.

† United States, Department of Agriculture, Farmers' Bulletin No. 300.

The grass gives, when liberally manured as described with guinea grass, a very heavy yield of somewhat coarse but sweet, tender, and nutritious fodder. The yields in Poona have been already given. These obtained elsewhere are of the same order. Twelve tons per acre have been obtained in Texas for two cuttings, the grass being grazed after the second of these was taken. In Florida three or four cuttings are obtained annually, making in all from six to eight tons of hay, equal to 13 to 16 tons of green fodder per acre in each year. In dry places, on the other hand it is no use. In Texas where irrigation was not available, and where, though it rained every month the annual rainfall was only 20 to 25 inches, it gave no growth and quickly died out.\*

It grew well under irrigation, but was awkward to manage, owing to the thick mass of stems which quickly form on the ground. With eight irrigations in the season, it gave over  $4\frac{1}{2}$  tons of green fodder per acre in Texas.\*

The fodder given by para grass is, as has been stated, coarse but sweet and nutritious. Analyses of the grass in the West Indies gave the following figures † for the green grass.

Water	... 72.9
Ether Extract (oil &c.)	... 0.2
Proteids (Nitrogen $\times 6\frac{1}{2}$ )	... 1.4
Digestible Carbohydrates	... 13.8
Woody fibre	... 9.6
Ash	... 2.1
	--- 100.00

It can be fed at any stage, and while with us it has been always used for cutting and feeding green, it has a very good reputation as a pasture grass. One authority says no other cultivated forage crop has been eaten with the same persistence and regularity in all stages of maturity as has this grass.‡ It is not injured by moderately heavy trampling or close grazing, though it will not stand very heavy treading of cattle or very close grazing. There seems no record of its use for silage or for making hay.

Para grass is injured and ruined by the least touch of frost, and thus its utility is limited to the part of India where frosts are not likely to occur.

When it is desired to get rid of the grass, all that is required is a very shallow ploughing followed by a thorough raking. As the runners are entirely on the surface of the ground the difficulties found in eradicating many of the perennial grasses do not occur in this case.

While it must be considered that the experiments so far made in Western India do not justify the recommending of para or Mauritius water grass in all our conditions and in all our climates, there is evidence to show that in damp semi-waterlogged places, on the banks of canals, tanks, and ditches and in similar situations it does bid fair to be a grass producing heavy yields of good fodder, and giving crops right through the year.

\* Hastings—United States Department of Agriculture, Bureau of Plant Industry Circular No. 106 (1913).

† Watts—West Indian Bulletin, Vol. III (1903).

‡ Guam Agricultural Experiment Station Report, 1914.

## RHODES GRASS.\*

This exceedingly valuable fodder crop which has very great analogies in method of growth with the para grass just described, originated from South Africa where it was introduced into cultivation by the late Mr. Cecil Rhodes on his estate near Cape Town, and quickly became popular as a useful fodder grass. Here it was seen by emissaries from the United States and Australia, and it was by them introduced into their own countries. It made more rapid progress in the latter country than in the former, but in both it has now become established as a very useful fodder in the parts of the country not subject to frost, and experiments made at Bangalore† indicate that it has quite probably a large field in Western India. It was stated on introduction to be capable of thriving well on inferior soils in regions of light rainfall and of resisting long periods of drought.

The experiments at Bangalore justify the following statement of the methods of cultivation of the grass which have given successful results and the yields which may be expected.

Rhodes grass appears to grow well on any kind of land except stiff clay, though it does best on light porous soils which do not form a hard crust after rain or irrigation. In heavier soils it is essential to keep the surface well cultivated and open. It has not been successful on black cotton soil. The land should be level and well bunded and should be well drained to prevent waterlogging, as this is fatal to the crop. If sown on sloping land it is not likely to do well after the first year on the upper parts, as the soil will be washed away from the roots.

The land must be absolutely clean when Rhodes grass is sown. Other grasses, especially *dub* or *hariaali* (*Cynodon dactylon*) will ruin the plantation by choking the seedlings before they are established. It seems wisest to plant Rhodes grass on land which has been previously under crops. The land should be ploughed deeply (six inches at least), and a fine tilth obtained by harrowing. Usually a topdressing of old stable litter two inches thick may be put on and hoed in with much advantage, while heavy rich lands have benefited by adding a dressing (two inches thick) of coarse sand.

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\* There has been a lot of confusion as to the botanical identity of the grass known as Rhodes grass. It was originally introduced to America as *Chloris virgata*, a grass which occurs very commonly in India, and is a very ordinary pasture grass. On this account Rhodes grass has often been considered as not likely to be of much value. The cultivated grass is, however, quite a different, though botanically a similar, species, and it is identical with *Chloris gayana*, a grass originally obtained from South Africa. Dr. Burns and Mr. E. K. Bhide of the Economic Botanist's Department (Bombay) have kindly described for me the botanical differences between Rhodes grass and *Chloris virgata* growing under the conditions of Western India. These are as follows:—

	Rhodes grass ( <i>Chloris gayana</i> )	<i>Chloris virgata</i> .
3rd glume	Sparingly hairy, awn short	Very hairy, awn long.
5th glume	Very shortly awned	Reduced to a clavate body.
6th glume	Reduced to a clavate body	Non-existent.
Spikes	Long	Short.
Habit	Robust and erect	Weak and spreading.

† My account of Indian experience with this grass is almost entirely derived from notes recently published by Home and Draper on the experiments at Bangalore (Army Headquarters India, November 1915). These notes are issued, however, as purely provisional.

If the crop is to be grown without irrigation, the sowing is done when the monsoon begins, and about ten pounds of seed seem to be needed per acre. The seed used was obtained from Australia, and has been of very variable character. Several other grasses (*Panicum sanguinale*, *Panicum crus-galli*, and *Paspalum dilatatum*?) have been received as Rhodes grass, and care must be taken that the right grass is sown. The seed is sown broadcast either after rain (when the land should be lightly harrowed before sowing), or when rain is expected. A lever or brush harrow should be passed over the land after sowing. The seedlings appear from seven to fifteen days after sowing, or after the first fall of rain.

When about three weeks old the seedlings will generally appear as a series of almost flat inclined shoots, branching out in all directions from the centre root. They grow in this manner till a length of about nine inches has been reached and then throw out runners from the joints nearest the ground. These runners shoot out all around and keep parallel to the ground surface, and they root whenever a joint touches the ground. Before any large amount of upright growth occurs these runners will cover the soil, and so if thin seeding is adopted, a longer period will elapse before substantial growth of fodder will take place. The runners will extend a long way, even up to ten feet having been measured, and they should be trained to run in the direction of any bare patches which may have occurred. All weeds and especially all other grasses like *hariali* should be carefully eradicated at this stage.

When the erect shoots, which form the plant as established in the ground, are grown up well and are in full flower, the first cutting can be taken. The grass should be cut with much care and a stubble of three or four inches left behind. This will leave all the runners behind. Home and Draper remark here that on no account should the *kurpa* be used for cutting the grass; if it is cut by hand the *jabau* is the best country implement.

After the first cutting the soils should be opened up between the roots, weeds and other grasses removed, and any roots pulled up during cutting replanted. It is stated to be advisable to open up the soil after every cutting and to put a light top dressing of old stable litter in addition after the last cutting of the season before the hot weather, which can be worked into the soil when the latter is opened up. This will enable the plants to keep green in the absence of irrigation, and even to grow to a certain extent.

If irrigation can be applied, the procedure recommended above can still be employed, but the crop can be sown at any time of the year except in the very cold weather. The land is best divided for irrigation into plots twelve feet square. Under irrigation the mass of runners on the surface of the ground is not formed after the plant has germinated except on the edges of the plots. It will consequently reach a height of three feet in thirty-five to forty days, but will flower slowly, and in the case of the first growth should be cut before it flowers. This is best done by hand three inches from the ground. During this time one irrigation every ten days will be sufficient except on very porous soils. Too much water should not be given, and the application only made when the soil appears unduly dry.

After every cutting the plots should be irrigated and soil should be loosened, and opened up. The new growth commences almost immediately after the first cutting, and reaches a height of from three and a half to four and a half feet in a month, and is heavier in the stem than the first, with many flowers. It should be cut in the flowering stage and never left longer.

Ten cuttings have been obtained per annum, if manuring is liberal. This can be given in the form of sullage water (as at Bangalore) when this is available for irrigation, or, if not, a very light dressing of old farm yard manure or stable litter after each cutting is a good thing. Fresh stable litter is not recommended.

The yield of Rhodes grass has been very high during 1914 and 1915 at Bangalore, and on the basis of experience there it is stated that the following yields may be expected.

- (1) From lands irrigated with sullage water and drainage from cattle stables, ten or eleven cuttings yielding 218,000 pounds of green fodder per acre per annum.
- (2) From lands irrigated from wells seven or eight cuttings yielding 100,000 pounds of green fodder per acre per annum.
- (3) From lands not irrigated, three or four cuttings yielding 41,500 pounds of green fodder per acre per annum.

These results are only on the basis of experiments made between 1913 and 1915, and only time can show how far these yields can be maintained.

The following are the special points in this cultivation to which the Bangalore experiments call attention :—

- (1) It is wise to make sure by experiment on a small area whether the soil and climate are suitable, and also, if irrigation is available, what is the best time of the year to sow. It is suggested that in the latter case sowings be made every ten days throughout the year to ascertain the best season.
- (2) It is not wise to attempt to put Rhodes Grass on old grass lands which are already giving fair yields, and it is really only recommended for trial on lands which it is desired to put newly under grass.

The growth of the crop from seed has been described, but it can equally well be put out by planting small rooted shoots on irrigated land or in the rains. Small bunches of eight or ten young shoots each are cut, with the roots, from the sides of old tufts, and the tips are trimmed off leaving the cuttings about eight inches long. These are planted out in the ground one foot apart, and will quickly take root, and throw out runners until the whole area is covered. This method is slower than that from seed, but is more certain, and can well be used to fill in gaps in a field of Rhodes grass.



So far as unirrigated Rhodes grass is concerned, the conditions of Bangalore are by no means so severe as those of the greater part of Western India. The average rainfall in Bangalore and in three or four centres of Western India is as follows :—

	Bangalore.	Poona.	Ahmednagar.	Belgaum.	Ahmedabad.
	ins.	ins.	ins.	ins.	ins.
January	0.2	0.1	0.1	0.1	...
February	0.1	...	0.1	...	0.1
March	0.6	0.1	0.1	0.4	...
April	1.3	0.7	0.3	1.7	...
May	5.0	1.4	0.8	2.6	0.3
June	3.2	5.2	4.6	8.4	3.8
July	4.0	7.6	3.2	15.7	12.5
August	5.9	3.7	3.0	8.9	7.6
September	6.3	5.0	7.0	4.8	4.3
October	6.4	4.3	2.9	5.0	0.4
November	1.9	0.9	0.8	1.4	0.4
December	1.7	0.3	0.6	0.3	...
Total	35.6	29.3	23.5	49.3	29.1

Whether Rhodes grass is likely to be suitable as an unirrigated crop with us is therefore very doubtful, and the further north we go the greater is the doubt. On the other hand, if irrigation is used, there seems no reason to suppose that it will not do well wherever there is suitable soil, and it is well worth serious experiment. How far the yield of the grass will be maintained is still a moot question even in Bangalore, but apart from this and the possibility of frost in the more northerly parts of the Bombay Presidency, there seems considerable prospect of its being a very valuable addition to our fodder resources, filling a place similar to that occupied by guinea grass, and that might be also taken by para or Mauritius water grass.

The grass is a very nutritious one. "Horses and cattle eat it with relish, and the grass, though its stems are succulent does not contain an unduly large proportion of moisture even during the rainy season or when grown on irrigated land."\* In the West Indies it is considered as a grass to improve poor animals† and in Australia, it is looked upon as more nutritious

\* Home and Draper—*loc. cit.*

† Agricultural News of West Indies, Vol. XIII (1914).

than *Paspalum dilatatum* being richer in proteids and poorer in fibre. Its composition varies very much at different stages\* and at a stage when suitable for cutting is shown in the following analyses, the grass being air dried before analysis. The first two are samples from Hawaii,† the third is a sample from Bangalore done in my laboratory.

	Hawaii Samples.		Bangalore Sample.
	p. c.	p. e.	p. c.
Water	11.7	9.8	5.4
Ether Extract (i. e. fat & c.).	2.3	1.4	1.0
Proteids	6.1	7.3	8.5
Digestible Carbohydrates	42.5	44.7	44.9
Woody Fibre	80.2	29.2	87.7
Ash	7.2	7.6	7.5
	100.00	100.00	100.00

The Bangalore sample is thus distinctly the most fibrous.

The grass has only been grown in India so far for feeding green. It is said, however, to make excellent hay if cut in flower. If cut later, it is too coarse and fibrous to make good hay. In any case, the curing of the hay requires much care. If not cured enough it easily becomes mouldy if too much it becomes dry and fibrous.‡ I have no evidence at present as to its suitability for silage.

## IX SUGGESTED GRAMINEOUS FODDER CROPS.

In the present section I propose to speak of two or three grasses which have been suggested for introduction in Western India, as they have filled a real need in climates and conditions which are not widely different from those existing here. In doing so, I can only indicate the success they have had elsewhere, and the place they may possibly fill with us. Experiment can only decide how far such anticipations are justified.

### RED TEFF GRASS.

A grass which has recently been strongly recommended as likely to be useful in the drier districts of India is red teff (*Eragrostis abyssinica*). Originally coming from Abyssinia, it was imported about twenty to thirty years ago into a number of other countries and notably into South Africa and India.

\* See Agricultural Gazette, New South Wales, Vol. XXI (1910).

† Thompson—Hawaii Agricultural Experiment Station Report (1903).

‡ Hungerford—Philippine Agricultural Review, Vol. V (1912).

Experiments in India were not carried out very widely, and interest in it died out. But in the meantime the Raja of Jashpore grew it, and he reported that "the straw or grass is 4 to 4½ feet in length and smells sweet".\* At the Saharanpur Gardens,† it was considered a failure as a good grain, but a success as a fodder. It yielded, when sown in July and cut in August, a crop of 16,000 pounds of green matter per acre, giving hay of very good quality, being preferred to *jowar* straw (*kadbi*) by bullocks. It was suggested that it was likely "to become the rye grass of India." Interest in it, however, soon died out, especially as some seed introduced as a drought resisting grain crop for relieving famine seems to have been an inferior sort totally useless for the purpose.‡

As a result no further experiments with this grass were done for many years. Interest in it has recently revived, and Prain in July 1915 stated that he considered it possibly suitable to areas in the South Western Punjab, Rajputana, Central India, Hyderabad and Mysore. As the climate of much of Western India does not differ widely from that of some of the places named, it would possibly also do well in the area of which we are treating. During the last two years experiments have been made with it at Cawnpore§ which give us more than inference in considering its possibilities in India.

At Cawnpore the variety known as "Teff tseddia" was sown on December 5th, and 25th, and on March 1st. That from the first sowing gave 11,410 pounds per acre of green matter in two cuttings, the first cutting (8,560 pounds) being taken in flower on March 17th, the second (2,850 pounds) when seed had set on May 23rd. The seed sown on December 25th gave three cuttings with a total yield of 12,732 pounds per acre of green fodder: the first cutting (7,722 pounds) was taken on April 12th after the seed had set, the second (2,855 pounds) on May 15th, and the third (2,155 pounds) on June 25th. The plants put in on March 1st only gave 6,171 pounds per acre in two cuttings: the first (4,004 pounds) was on May 9th, the second (2,167 pounds) on June 23rd. Of course this was grown under irrigation in each case. In the following year, sown in November, it yielded 14,360 pounds of green fodder per acre with six waterings and three cuttings, the bulk of the yield being given by the first cutting in March. Sown in March it was again a failure, it gave no cutting before the rains, and a very little after; sown in July it yielded so little as to be unworthy of consideration.

Another variety "Teff hagaiz" grows more slowly and in the rains; the yield was small and as a crop it is not worthy of consideration.

Those experiments would seem to indicate that in the United Provinces if teff grass is used it is only likely to succeed (1) as an irrigated cold weather fodder crop, (2) if the rapidly growing varieties "Teff tseddia" are grown. Under these circumstances it gives about five tons per acre of good green fodder, which is readily eaten by horses and cattle, and which cures well for hay.

Beyond this there is no Indian experience, and I must quote that obtained in South Africa, chiefly from the work of Davy. He describes it as an annual grass of Abyssinia, leafy and good in quality, two to four feet high

\* Agricultural Horti-Society of India. Proceedings, 1888. Quoted by Davy, Kew Bulletin, 1913.

† Gollan—Saharanpur Garden Report, 1888.

‡ Davy—Kew Bulletin, 1913.

§ Cawnpore Agricultural Station Report, 1914 and 1915.

with much seed. It is said to grow rapidly in South Africa, maturing in seven to eight weeks from sowing, and if cut before the seed develops, to give a second crop. The seedlings are not affected by extreme heat. Stock eat it readily both green and as hay.

The purpose which teff may fill in Western India, as already suggested by the result of the Cawnpore experiments, is as a cold weather fodder grown under irrigation. It would be sown broadcast in the way already described for the millets, in November or December, and would be cut for direct feeding. It is not likely to pay to grow it for hay or silage. It requires seven pounds of seed per acre. It is important that the rapid growing "teff tseddia" be obtained, as some of the other varieties sold are quite useless under our conditions. Such seed can be now obtained in quantity from the Agricultural Supply Association, Ltd., Johannesburg, South Africa, at about Rs. 20 per 100 pounds. It will cost a little over Rs. 1-4-0 per acre for seed at the rate above given.

The air dried grass grown in South Africa and at Cawnpore gave the following figures on analysis :—\*

	South Africa.		Cawnpore.
	(1)	(2)	
	Per cent.	Per cent.	Per cent.
Moisture ...	8.88	9.16	6.95
Ether Extract (oil, &c.) ...	1.21	1.07	2.01
Proteids ...	6.21	4.72	4.06
Digestible Carbohydrates ...	39.08	42.71	51.43
Woody fibre ...	39.07	35.63	29.35
Ash ...	5.35	6.71	6.20
	100.00	100.00	100.00

Though these analyses show a good nutritious fodder much like oat hay I confess I cannot see much future for teff under our conditions. It would seem that as a cold weather fodder crop grown under irrigation, better yields can be obtained with maize or shalu jowar and equally quickly, while if a finer fodder is wanted teff seems to have little advantage over oats as a fodder crop. It is, however, worthy of further testing in view of the high claims made for it in South Africa.

#### SUDAN GRASS.†

Sudan grass, which has only been recently introduced into this country may prove to be a fodder crop of considerable value in Western India. As its

\* Ingle.—Transvaal Department of Agriculture, Annual Report 1906-07 and Cawnpore Agricultural Station Report, 1914.

† As has already been stated when considering *Andropogon halepensis* or *baru* there has been a good deal of confusion in the naming of these grasses in India and sometimes elsewhere, and the name "Sudan grass" has been applied to that grass. This is unwise and only leads to confusion. The name "Sudan grass" was introduced by the Americans in 1909 to describe an annual grass of which a description is here given, which in agricultural habits is totally different from *Andropogon halepense*, and I think this is the use which ought to be maintained. The grass here described, genuine Sudan grass, has hardly been cultivated here at all to my knowledge except in the smallest of experiments.

cultivation is as yet quite in the experimental stage, I shall have very largely to rely on experience elsewhere in the description given, but the results so far obtained here are encouraging.

In the United States, where it was introduced in 1909 from Egypt, it is said to be likely to fill a long felt want for a hay grass for the south, and probably to replace millets largely as a catch crop in the Central and Eastern States. While it does not do well in places with high altitude, or where the nights are cool, there seems to be a place for it also in irrigation regions as a fodder to mix with lucerne.\*

Sudan grass† is a tall annual grass growing from six to ten feet high when widely spaced, but four to five feet high when grown thickly. The stems are fine, rarely thicker than a lead pencil. There is abundant tillering when it is thickly sown, but it forms no rootstocks and hence never tends to become a weed. The stems are leafy but erect, and seldom lodge. The grass is sweet, although the percentage of sugar is low. The seed head of the grass is a long loose open panicle from six to eighteen inches long. It is adapted to the same conditions as the *jowars*, but will grow with a lower temperature, and under similar conditions it ripens earlier than any of them. It is as drought resistant as *jowars*, but will grow in wetter climates than these latter, though in wet conditions it is apt to become coarse.‡

The crop is sown broadcast, drilled in close rows (say nine inches apart) or grown in rows widely spaced which are cultivated between. The broadcasting or close drilling methods are the best, as otherwise the fodder is likely to be coarse. Thirty pounds of seed per acre are required in this method of sowing.§

Sudan grass gives a large crop of hay in a short time, and hence would replace several of the millets for this purpose, and some of the quick growing fodder *jowars*. It gives, however, better hay than the millets, and is cured with equal ease. It can be cut twice, thrice or even four times under conditions similar to ours, if the soil moisture is sufficient or if irrigation is given. It has been found to give from three to four tons of hay per annum under favourable conditions where three or four cuttings are possible. It can be grown in mixture with leguminous fodders (*chavli* or *val*).

The seed is not shaped like *jowar*, but more like barley and about one third the length, and is very similar to that of *baru* (*Andropogon halepensis*) from which it can be only distinguished with difficulty.¶

#### ELEPHANT GRASS.

There is one other grass which, though experiments have never, to my knowledge, been made in India with it, seems to possess decided possibilities as a fodder crop, namely Elephant grass or Napier's Fodder (*Pennisetum purpureum*), which has recently leapt into prominence in Rhodesia, South

\* U. S. A. Farmers' Bulletin No. 605.

† In this description I quote largely from Piper-Forage Plants.

‡ Philippine Agricultural Review, Vol. IV (1911), page 394.

§ If it is to be grown for producing seed, much wider spacing in cultivated rows is of course necessary.

¶ This difficulty of distinguishing the seed is probably the source of the confusion in these grasses to which I have previously referred.

Africa, as a drought resisting grass.\* It attracted attention in the first instance by the way in which it remained green when other grasses became brown, and by the way in which it is relished by stock. It is a common grass in South Central Africa, but has only recently been cultivated as a special fodder crop.

It is planted not by seed but by cultivation of roots, or by cuttings, or by rooted slips. The last gives probably the best results. These rooted slips are planted singly in rows, four feet apart, and with three feet between the plants. If cuttings are used, they should be taken from mature plants, each being 18 to 24 inches long, planted slantwise with two thirds below the ground. In any case it is said that alternate rows of plants can be removed after two or three years.

This crop is said to show remarkable resistance to drought and frost, but responds readily to irrigation. If water is liable at any time to lie, it is not suitable; and under these conditions, in South Africa it is considered that it can best be replaced by *Paspalum*. On dry situations, with red or sandy soil, or in cold localities it does very well indeed.

As an example of what it can do, in Rhodesia it was planted in March 1911, and was cut down in August of the same year to provide cuttings for further planting. It gave the first cutting of 1912 in February, and then gave crops on March 30, May 30, and June 30.† At the first and second cuttings it was four feet high, and the third and fourth it was 2½ feet high. This was in a year when there was no rain after the end of April, and the total rainfall was 21 inches. In 1913 it was cut twice when the plants were from six to seven feet high, with no sign of flowering. At each cutting from twelve to fifteen tons of green fodder per acre were produced.

Elephant grass is a somewhat fibrous grass, but is highly relished by cattle. It gave, when freshly cut, the following figures on analysis:—

	Per cent.
Water	61.81
Ether Extract (oil, &c.)	0.29
Proteids (nitrogen x 6.25.)	2.92
Digestible carbohydrates	17.29
Woody fibre	14.77
Ash	2.92
	<hr/> 100.00

It is not suited for making hay, but gives very good green fodder, and makes good silage. And it is thus a heavy yielding grass, which seems likely to have possibilities as a perennial fodder crop on good dry land under the conditions which prevail over the larger portion of Western India.

#### MARVEL GRASS.

A local grass to whose possible merits as a fodder crop Burns‡ has recently drawn attention is *Marvel* (*Andropogon annulatus*) one of the best and

\* Rhodesia Agricultural Journal, Vol. X (1913), Nos. 3 and 6.

† The corresponding times in Western India would be (1) for planting—September, (2) cutting down to provide cuttings for further plants—February, (3) first cutting, August, and then successive crops at the end of September, November and December.

‡ Agricultural Journal of India, Vol. X (1915), page 290. The account given is taken in all essentials from his description.

most appreciated of the wild fodder grasses of the Bombay Presidency. It is also known as *ginja* (Panch Mahals), *sheda*, *sam-payen*, and *palwan*. It thrives best in heavy rainfall tracts, and requires a well drained situation. It spreads along the ground to some extent sending out roots at the nodes like so many of the other good fodder grasses. It is highly relished by cattle, who will sort it out of a mixture and eat it first. As a green succulent fodder it is stated to give good results in milk production, and though, hitherto usually either grazed or fed green, it makes good hay. It gets very coarse after flowering, and so for hay making should not be cut at a later stage than this.

Seed sown at Poona in 1911 has given crops in good garden land each year since from the original stumps. It is hence a perennial, but the yields were only large in 1913. They were as follows :—

1912 . 8,200 lbs. green fodder.

1913 119,200 „ do.

1914 8,400 „ green fodder and 3,200 lbs. dry fodder.

Under ordinary dry cultivation in good land in good conditions in Poona, it keeps green till December and then turns brown. In April and May it is quite dry but grows quickly when the rains commence, growing to five feet high on good land. It responds well to cultivation, and the ground should be stirred after each cutting. If this is done it has been kept green until March.

The ripe seeds germinate readily if sown in thoroughly tilled land soon after the first showers of the monsoon ; the seedlings must be well established before the really heavy rain comes.

Analyses of the fodder grown at Poona gave the following results ;—

	Before flowering.	In flower.	In seed.
	Per cent.	Per cent.	Per cent.
Moisture	69.9	65.9	65.4
Ether extract (oil, &c.)	1.6	1.7	1.7
Proteids (nitrogen x 6.25)	2.1	2.2	2.0
Digestible carbohydrates	13.5	14.9	13.8
Woody fibre	9.2	11.6	14.3
Ash	3.7	3.7	3.3
	100.0	100.0	100.0

At present, the seed is not available in any quantity, but if further experiments prove that it is worth cultivating as a special crop, this will doubtless be a difficulty soon removed.

## X. LUCERNE.

Perhaps the most important leguminous fodder crop in the world, and certainly the one which occupies this position in the drier parts of almost every continent is lucerne. This crop stands unique in being able under a very large variety of conditions to produce a continual succession of cuttings of very rich fodder, while being unaffected by all but the most extreme heat and by cold down to the freezing point, and by being able to grow in almost any soil in which it has been tried in Western India. It is at present the only purely fodder crop cultivated on a large scale in this part of the country, and its cultivation has extended considerably in recent years and is still extending.

Although lucerne has been considered as certainly a plant native to Western Asia,\* and hence might have been thought likely to be largely used in India from time immemorial, there is no evidence of its having been grown here more than a hundred years. It seems certain that it has entered India from the north-west, for seed is still largely obtained from Baluchistan, Afghanistan, Kashmir, and other countries approached from the north-west, and in these countries it is grown on a very large scale. It is interesting to find that the extension of its cultivation has closely followed the needs of military horses,† and until quite recently the military cantonments have been the great centres of lucerne growing in Western India. It is impossible to give the area which it occupies, because it is not separately recorded in the Government statistics, but a large—perhaps the greater—part of the area under “Fodder Crops” is occupied by lucerne.

*Climate Required for Lucerne.*

Lucerne is the typical leguminous fodder crop for semi-arid tracts of country when the temperature does not go very low. So far as heat is concerned, it seems to be able to stand all but the very highest temperatures. Over the greater part of Western India, with a hot weather temperature rising to from 105° to 110° F. it does perfectly well,—and in the Punjab where it rises even higher, the crop is still a success. In Sind, however, the limit appears to be reached, and after many trials at Mirpurkhas, Henderson ‡ reports that it does not grow well or yield well. “The hot weather seems to be too much for it.” It only lasts a short time and is not able to maintain itself against weeds. The temperature in Sind, however, reaches 120° to 125° F. or over in the hot weather, and these are conditions which are not reproduced in many other parts of India.

As far as cold is concerned, different varieties of lucerne differ very much in their capacity for frost resistance. There is no part of the Bombay Presidency, except Sind—where the crop can be hardly recommended,—where the frost received is serious enough to damage a stand of any varieties

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\* De Candolle.

† Mollison—Text Book of Indian Agriculture, Vol. III, page 229, and see also Thompson, Agricultural Journal of India, Vol. IV, page 319.

‡ Report, Mirpurkhas Agricultural Station, 1913-14.



of lucerne which are grown here. There is very rarely more than two or three degrees of frost even in Northern Gujarat, and this, though it may damage the actual fodder on the ground, does not seriously affect the plants themselves. The conditions in Northern India are much more severe but even there, by judicious selection of the seed of varieties from regions further to the north,—Kashmir, Turkestan, &c.,—there need be no anxiety on account of liability to damage by frost.\* Certain varieties are so cold-resistant that they are grown in the northern parts of Siberia (Yakutsk).

While fairly resistant to extremes of heat and cold in a dry region lucerne is very delicate under conditions of moderately high temperature accompanied by a moist climate. In India a rainfall of much over 40 inches per annum, while it does not prevent its cultivation, does prevent it being a perennial crop. In Bihar, for instance, it grows, but soon dies out, and cannot be maintained for several years as in the greater part of Western India. In regions below the Western Ghats, with a high rainfall,—the Konkan and the greater part of Thana,—lucerne is a failure as a permanent crop. It always becomes unhealthy and generally dies in the rainy season. In this part of the country if grown at all it must be as an annual crop after the rains are over. This has been recommended and it then does well, but whether as such an annual crop lucerne has many advantages over many others is a doubtful point. It may generally be considered that unless lucerne can occupy the land more than one year, it can advantageously be replaced by other leguminous fodder crops which give a yield more quickly and a greater crop for the money expended than lucerne supplies in the one season. Under certain of our conditions berseem supplies such a crop, and there are others. How far these will supply such a crop in the Konkan will be discussed later.

In all considerations of the suitability of lucerne for any locality, this extreme sensitiveness to long continued moist conditions of atmosphere, especially when the temperature is high, must be taken into account. And the fact that this crop is essentially one for dry atmospheric conditions must be always recognised. At the temperatures we have in India, it is doubtful whether it can be really successful except as an irrigated crop,—as the conditions under which the soil moisture is sufficient for its growth are usually those where the atmospheric moisture is too high to give success to lucerne as a permanent crop.

#### *Varieties.*

As a result of recommendations of drought resistant varieties of lucerne a number of attempts have been made to import such varieties into Western India and grow them without irrigation. These have always failed, as perhaps might have been expected when we consider how much more severe and long is the drought with us than in most of the countries in which they have so used. I will give two or three examples.

In 1906-07 Turkestan lucerne was imported from America as a drought resisting variety, and was planted at Dharwar and Dhulia. At the former place † it germinated well and flourished during the rains. After the rains

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\* Very interesting experiments on the cold resistance of different kinds of lucerne are detailed by Braad and Waldron in the United States Department of Agriculture, Bulletin No. 185, Bureau of Plant Industry.

† Report, Dharwar Agricultural Station, 1906-07.

were over it quickly began to suffer. In cuttings during the rains about 2,200 pounds of green fodder per acre were obtained. Leaf blight then appeared. After it was evident that it would die without it, irrigation was tried, and the plot was manured with farmyard manure. But all was in vain and the plots had to be ploughed up at the end of December. This applies, to an almost equal extent, to four strains of Turkestan lucerne. In Dhulia, \* the same four strains as were tried at Uharwar were grown, being sown by hand on June 27th. They germinated evenly and grew till the rains ceased in September giving an average yield in the first two cuttings of 2,600 pounds of green fodder per acre. After the rains were over they commenced to dry up. Irrigation had to be given on September 21st, and regularly afterwards almost as with the ordinary lucerne used here.

Argentine Lucerne, imported specially as a drought resister and put in at Manjri, † where lucerne is regularly grown, in 1909-10, grew very well at first giving a fair return in the early cuttings. But it failed as a dry crop, and was found to be not suited to the methods of cultivation. At the College Farm, Poona, ‡ it gave a smaller yield than the local varieties in the early cuttings, but afterwards yielded better as it had a longer and deeper root stock. But it had to be irrigated, and was no use as a dry crop. The stalks were thin and the leaves smaller than the local varieties, and it did not seem to have enough advantages as an irrigated crop to make it worthwhile pushing its cultivation.

Any attempts to grow dry lucerne under our conditions has, in fact always had the same result. The plants have died, or have only been kept alive by irrigation.

There are said to be three varieties usually grown in India§ — the Kandahar or Quetta, the Persian, and the Meerut. I know nothing of the third, and those cultivated in Western India are the first two of these. The essential difference between them is that the first has a trailing habit of growth, while the second is upright. Under most circumstances the latter—Persian or Arabian—is to be much preferred. With regard to the two varieties Mollison ¶ remarked "The Kandahar variety is sparingly grown, but is not a variety to be recommended. The stems have a trailing habit of growth, the leaves are small and each time the crop is irrigated, the lower branches are submerged, and thereby the leaves get yellow and fall off. The Arabian lucerne is much more upright and vigorous in its habit of growth."

The Persian or Arabian lucerne generally grown here has hairy, large leaflets, grows very rapidly, and is said to die earlier than most other varieties. It produces more cuttings per season than the other type.

The Quetta or Kandahar lucerne, as already stated, has a trailing habit and small leaves, and is awkward to manage under irrigation conditions of cultivation. It gives fewer cuttings per year than the ordinary lucerne, but has done very well in Northern Gujarat, much seed having been distributed in the alluvial (*goradu*) soil areas. The seed of this variety is cheap, and there is always a tendency for it to be substituted for the other type. Its seed is, however, somewhat smaller. Some years ago, without realising its disadvantages, a great deal of the seed of Quetta lucerne was sold

\* Report, Dhulia Agricultural Station, 1906-07.

† Report, Manjri Agricultural Station, 1909-10 and 1910-11.

‡ Report, Agricultural College, Agricultural Station, 1909-10.

§ United Provinces Agricultural Department, Bulletin No. 6 (1911).

¶ Mollison—Text Book of Indian Agriculture, Vol. III, page 230.

and spread in the Deccan, and the growers were very disappointed with the resulting plants and crop. The only area in Western India in which it has been a success is, in fact, the alluvial area of Northern Gujarat.

### *Soils for Lucerne.*

Our experience is that lucerne will flourish on practically any soil in Western India provided it is not waterlogged, provided it is not highly charged with salts, and provided water is available in sufficient abundance. Undoubtedly the best conditions are shown, however, by a deep loose soil. Mollison\* from Western India experience, says that "it shows its best results. . . . on deep friable loam soils, with a limestone subsoil, and with a liberal application of suitable manure. It does not do well on black or heavy soil, because such land is unsuitable for irrigation. It does fairly well on light sandy loam." Since this was written, a good deal of lucerne has been grown with success on black soils, and provided these do not contain excess of salts, there seems no reason why it should not succeed. It is a little more difficult to establish the plants, and the ridge system of planting seems essential, but otherwise success can generally be obtained.

It is impossible, however, to insist too strongly on the necessity of thorough drainage for lucerne. It has been stated in America † that it will not do well where water is nearer the surface than six feet. This is hardly the experience here, but the necessity of keeping its roots out of any standing water must be recognised. It is very unwise to sow on a field at all liable to be flooded and the success of the ridge system of planting is probably largely due to the fact that it makes the plants less liable to stand in water for any length of time.

Lucerne seems, moreover, fairly sensitive to salts in the soil. It has never flourished with us on land containing much salt of any kind,—which, with us, usually consists chiefly of chlorides,—or on soil watered with brackish irrigation water. It has been stated by American authorities ‡ that it is fairly resistant to the presence of sulphate in the soil, standing up to one per cent. of crystalline magnesium sulphate, or up to 0.7 per cent. of crystalline sodium sulphate without dying. The presence of a little salt was also considered to increase the drought resistance. It was found by Hilgard to tolerate much more sulphate than chloride or carbonate, being very sensitive to both these latter. § But on the whole lucerne is better avoided where there is any considerable amount of salt in the soil. Acid in the soil, even in very small proportion, is fatal,—and should be rectified by liming the land. It practically never occurs, however, in Western India.

### *Time for sowing Lucerne.*

Lucerne seed can in Poona be sown successfully at only two periods in the year. The first of these is in June, just at the commencement of the rains,—the other, and the more preferable, is from October to December. ¶ If sown at other times it is very liable to be seriously injured when young by aphid attack or by caterpillars when the seedlings are just above the ground.

\* Mollison—Text Book of Indian Agriculture, Vol. III, page 230.

† Coburn—The Book of Alfalfa, page 44.

‡ Traphagen—Montana Agricultural Experiment Station, Bulletin No. 54.

§ Hilgard—Soils, pp. 467 and 472.

¶ Poona Experiment Farm Report, 1893.

This limitation does not entirely apply to the same extent in the light soils of Northern Gujarat. There, experiments in 1913-14 indicate that it may be planted any time between September and December with almost equal success. The following table shows the yields obtained, the number of cuttings taken, and the number of irrigations required between the time of sowing and May 31st 1914.\*

Date of sowing.	Number of irrigations.	Number of cuttings.	Yield of green Lucerne.
1913.			lbs.
August	19	6	15,600
September	19	6	21,480
October	16	5	18,000
November	15	5	18,840
December	18	4	11,360
1914.			
January	11	4	13,680
February	11	2	1,280
March		Failed.	
April		Failed.	

The lucerne planted in August germinated well, but did not thrive, and gradually died. That put in in other months did well except that in February and later. From the February lucerne only two small cuttings were obtained and then it died: from that sown in March and April, nothing was obtained as the plants died in the hot weather.

It seems clear then that the best time for sowing in Western India is, as already stated, either June or from October to December, though possibly sowing a little earlier than October is satisfactory in districts with light well drained soil. It seems certain that if lucerne is to succeed, it must be well established before the hot weather. This is in agreement with the experience in Northern India.

#### *Methods of Cultivation.*

Whatever method of sowing is adopted it is absolutely essential that the land should be thoroughly cleared of weeds before lucerne is put in. The soil over much of Western India is foul with deep rooted weeds. Unless these are got rid off before lucerne is sown, the plantation will surely prove a failure, as the crop is not able to overcome these weeds. This is specially important when the bed system of cultivation is adopted, so that hoeing is impossible. The expenses in laying down a lucerne crop are very heavy, and so it is important that when once established it should last.†

\* Nadiad Agricultural Station Report, 1913-14.

† Mollison—*loc. cit.*

The method which has hitherto been adopted for sowing the crop, and in fact the one now most frequently used, is to broadcast the seed in beds about ten feet square, surrounded by small bunds six inches high, and each forming an irrigation check flooded at each application of irrigation water. "The seed is lightly covered with soil by means of a wooden rake. A through water gutter generally runs between each double line of beds, but the arrangement of the water channels is regulated by the evenness or otherwise of the field surface. Water is given every ten days in the cold weather or during breaks in the monsoon, every six to eight days in the hot season according to the character of the soil."\*

The present method of cultivation of lucerne in Sangamaer, which may be taken as typical of that in the Deccan has been described in a recent article by N. F. Mirza,† from which the following extracts are taken.

"Lucerne is sown at the end of October or in the beginning of November. The land is not left fallow in the monsoon. Some crop, generally *bajri*, which requires 3 to 3½ months for growth is sown early in the monsoon. Before sowing *bajri* the land is ploughed well, i.e., both lengthwise and cross-wise and made fine. Twenty to thirty cartloads of farm yard manure, and five to ten cartloads of household manure (house sweepings and ashes) are given per acre in the month of May. The manure is well mixed with the soil.

"When the first showers of the monsoon wet the land properly, *bajri* is sown. No mixture whatever is sown in the *bajri*, because after harvesting the crop the land must be clear in order to prepare for lucerne. Two hoeings and one or two hand weedings are given in order to clear every possible weed from the land. This helps greatly in the successful cultivation of lucerne later on. *Bajri* is harvested at the end of September or in the beginning of October and just after the harvest the land is ploughed both lengthwise and crosswise. The clods are broken and the soil is made fine. *Wafas* (beds), ten feet by ten feet, are made in order to facilitate the work of irrigation. No manure is given after the *bajri* crop. Lucerne seed is then broadcasted in the *wafas* at the rate of 12 to 16 pounds per acre. The seed is lightly covered and the land irrigated.

"Some farmers do not manure the land before sowing *bajri*. After the *bajri* harvest, the land is ploughed and *wafas* are made. Seed is broadcasted and then it is covered with manure instead of earth, at the rate of fifteen to twenty cartloads of manure per acre. This method is practised when the farmers do not get manure in the month of May or when they are busy in other operations. Some of the farmers apply poudrrette instead of farmyard manure, and these say that the lucerne from the fields manured with poudrrette grows more quickly than that from the fields manured with farmyard manure.

"On the bunds of the *wafas*, maize, onion, coriander, or radish or some of these are dibbled at the time of broadcasting."

This system has the disadvantage of not raising the stems of the plants out of contact with irrigation water, of not providing for the clearing out of weeds when the land becomes foul, and of resulting in the killing off of the lucerne if an exceptionally long wet period occurs in the rainy season. It has the advantage of giving a rapid crop, and provided all goes well,

\* Mollison—*loc. cit.*

† Poona Agricultural College Magazine, Vol. VI (1915), page 177.

gives heavy crops for the first two or three years. The disadvantages were, however, so great that a system of growing the crop on ridges was introduced by Mollison and this tends to extend slowly and displace the older one. His method was described by himself as follows :—\*

"The field should be well ploughed and brought into a thoroughly friable, smooth, clean condition during the rains. In September a liberal dressing of thirty loads per acre or more of thoroughly decayed farmyard manure should be given. Half rotten manure does not answer well, because it keeps the soil open. It does not supply the needs of the young seedlings at once, and white-ants are attracted to the field. The manure should be evenly spread and by subsequent ploughing and harrowing mixed thoroughly with the soil. Ridges are then formed. The seed is sown on the ridges which can be made 22 to 28 inches apart by an ordinary native plough. In practice it was found necessary to fashion the ridges afterwards into neat proportions with the hand hoe. The slope of the surface of the field will indicate the direction in which the ridges should be drawn.....A rather deep groove is made along the top of each ridge with a light hoe. The seed is best sown by hand. It should be carefully sown and carefully covered by not more than one and a half inches of soil. The whole operation rounds and flattens the ridges, and permits the seedlings to spring up in lines, covering a width of 3 to 4 inches. Crowding of the seedlings in dense rows is thus avoided. The importance of fine tilth is obvious, because the seed is small, and the seedlings very delicate till they take a firm hold of the soil. Frequent waterings are required during the first fortnight. The seedlings would probably wither if exposed on the top of a ridge to a hot wind unless sufficient moisture is within reach.....On medium soil, lucerne planted in the above manner requires water every eighth day in the cold season, and every sixth day in the hot weather, and oftener if the soil is light. Water should be given also during breaks in the monsoon."

Since the time when the above method was recommended first in Bombay numerous experiments as to the relative value of the bed system, as practised by the people, and the ridge system have been made in different parts of the country. I will quote the results of some of these.

At Poona, on medium black soil, not deep, there has been very little difference shown in the yields obtained. The following results were shown between 1910-11 and 1913-14 †:—

	Planted on ridges. Pounds per acre.	Yield.	Planted in beds. Pounds per acre.
1910-11	18,038		16,147
1911-12	29,920		27,040
1912-13	27,352		30,258
1913-14	12,191		12,944
Average	21,895		21,597

In this case the ridges were twenty-four inches apart: the beds were nine feet by six feet in size.

\* Mollison—*loc. cit.*

† Agricultural College Station Report, 1913-14.

On the deeper black soil at Manjri (Deccan) the ridge system gave considerable advantage. In 1910-11\* the yields were—

(1) On ridges—32,419 lbs. per acre at a cost of Rs. 162,

(2) In beds.—28,038 lbs. per acre at a cost of Rs. 154,

and this represents the relative result obtained under similar conditions on previous occasions.

At Surat (Gujarat) where we have to deal with deep and heavy black soils experience is similar. After years of experiment it was stated in 1908 that "the ridge system here is much superior to the bed system, as plants in beds die off after the first year and the land becomes infested with deep rooted weeds."† In this case the difference was much greater than in other places: the yields in the first and second years were as follows ‡:—

	Yield per acre.	
	1st year. lbs.	2nd year. lbs.
Grown on ridges	28,672	30,668
Grown in beds	18,327	19,289

Thus it is clear from these and other experiments that while on light and well drained soils the ridge system gives little if any better results in point of yield, in the heavier soils of our area it is essential to use the ridge system if the best results are to be obtained. In no case has this method proved less advantageous, and it would be a good thing if it was universally adopted.

The lucerne having been sown, it needs merely weeding, manuring, watering and cutting. We will deal with these matters in their order, as far as light is thrown upon them by experience in Western India.

*Weeding.*—The need for weeding commences almost at once, for the young lucerne plants, as already stated, have little power of smothering weeds, and deep rooted grasses very quickly kill out the lucerne. If the crop is planted broadcast in beds, hand weeding is the only resource, and must be done laboriously by women using the ordinary weeding hook of the country.

Even under the ridge and furrow system this method must be employed so far as weeds growing in the ridges are concerned. But the furrows, and hence the greater part of the land between the rows, can be kept clean with the ordinary bullock hoe. Mollison found the "planet junior" hand hoe the best possible instrument for the purpose. This, with all the extra parts, now costs Rs. 32-3-3 at Poona, and a very similar instrument at a smaller cost is now manufactured in Western India by Messrs. Kirloskar Bros. of Kirloskarwadi (District Satara). This, as used by Mollison for this purpose, is "fitted with grubber tines in front and an earthing up double mould board behind" and so "grubs up the weeds and earths up the ridges in one operation." As it can be adjusted to any width of furrow over eighteen inches, it may be used in practically all cases, and it leaves the furrows clean so that the water can flow properly. This should be done immediately after a cutting of the crop has been taken, and as frequently as the growth of the weeds demands.

\* Manjri Agricultural Station Report, 1910-11.

† Surat Agricultural Station Report, 1907-08.

‡ Surat Agricultural Station Report, 1905-06 and 1906-07.

*Manuring.*—If lucerne is to be really a paying crop it must be regularly and heavily manured. As already stated, a dressing of ten to twelve tons of well rotted farmyard manure should be mixed with the soil about a month before the planting is to take place, and this should be evenly spread, and by subsequent ploughing and harrowing mixed thoroughly with the soil before making the ridges. We have had no experiments to ascertain whether this farmyard manure can be replaced by other dressings.

Later on the usual recognised method of manuring is to give about five tons per acre of well rotted farmyard manure every third time the crop is cut. If such farmyard manure is not available, Mollison recommends three to four cwt. (330 to 450 lbs.) per acre of castor cake at similar intervals, and he considers that with this treatment the crop will be established in six months, and should last for years, yielding at least ten cuts per annum.

How far farmyard manure can be replaced by other manures has been the subject of a number of experiments. In 1892 three methods of treatment were compared at Poona, as follows, the seed being sown in June of that year:—

	Cost.	Yield to November 1892*
	Rs. a. p.	lbs.
I. Farmyard manure (15 tons before planting) (7 tons after every second cutting)	199 0 0	26,860
II. Castor cake. (7½ cwt. before planting) (8 cwt. after every second cutting)	143 0 0	29,824
III. Crushed Bones. (10 cwt. before planting) (4 cwt. after every second cutting)	150 0 0	27,088

This experiment with manures containing similar quantities of nitrogen shows little difference in the amount of produce. If anything, the castor cake has given the better yield for the money expended. <math>\leftarrow\rightarrow</math>

A recent experiment on the College Farm, Poona,† conducted for three years has dealt with the question as to whether, if a limited amount of farmyard manure only is available (as is often the case now-a-days), the remainder can be replaced by artificial manures. The artificial manures employed were sulphate of potash, and superphosphate, with, in every case, a very small quantity of sulphate of ammonia. The results were very marked as the following table will show. Eleven cartloads of farmyard manure were applied in each case each year, and the manures noted below were additional to this.

\* In nine cuttings. See Poona Experiment Farm Report, 1893.

† Knight and Patil—Agricultural College Farm Reports, 1912-13, 1913-14, 1914-15. Also summarised by Mann and Paranjpye in Bombay Agricultural Department Bulletin No. 79 (1915).



Additional manures per acre.	Cost of additional manure.	Average yield.	Increased yield over plot I.	Value of increased yield.
	Rs. a. p.	lbs.	lbs.	Rs. a. p.
I. Nil.	Nil.	18,711	Nil.	Nil.
II. Eleven cartloads farmyard manure extra	13 8 0	25,755	7,044	48 0 0
III. Sulphate of potash 167 lbs. Sulphate of ammonia 15 lbs.	13 8 0	27,705	8,994	72 0 0
IV. Superphosphate 243 lbs. Sulphate of ammonia 15 lbs.	12 0 0	30,500	11,789	94 0 0
V. Sulphate of potash 167 lbs. Superphosphate 243 lbs. Sulphate of ammonia 15 lbs.	24 0 0	29,573	10,867	87 0 0

This would seem to indicate that on the black soils of Western India artificial manures can profitably be applied to lucerne, that superphosphate is especially useful and needed, and that they can well replace, partially, the farmyard manure usually added. Mann and Paranjpye, on the basis of these experiments, suggest as annual manure applications for lucerne the following, under the conditions specified :—

- (1) 10 cartloads (4 tons) of farmyard manure per acre supplemented by
- (2) 200 to 250 pounds of superphosphate and 15 pounds of sulphate of ammonia.

The artificial manure in this case will cost, in normal times, about Rs. 12 per acre.

Lucerne has been very successfully grown, on the ridge and furrow system, when watered by sewage septic tank effluent. Experiments in this direction were carried out in the neighbourhood of Poona in 1899 to 1900 using effluent obtained in an experimental installation from Poona sewage. The results compare what could be obtained from (1) a dressing of twenty tons per acre of farmyard manure, and irrigating with canal water, (2) a dressing of twenty tons per acre of poudrette prepared from Poona night soil and irrigating with canal water and (3) using septic tank effluent only. The lucerne in each case was sown on May 8th, 1899, and gave its first cutting on July 19th the same year. It was irrigated with effluent four times before the second cutting; no effluent was given from August to November, and it was applied twice in November, twice in December, three times each in January, February and March, and four times in April or twenty-one waterings in all. Canal water was applied to all plots when needed. The yields obtained were as follow, in twelve cuttings :—

	Yield July 19th 1899 to May 2nd 1900.	Cost.	Value of crop.
	lbs.	Rs. a. p.	Rs. a. p.
(1) Farmyard manure and canal water	74,620	258 0 0	373 0 0
(2) Poudrette and canal water	96,180	332 0 0	461 0 0
(3) Septic tank effluent	1,02,088	174 0 0	510 0 0

The crop with the farmyard manure is a full one : the others are very large indeed. In the second year the crops on these plots were as follows :—

	Yield 1900-01.
	lbs.
(1) Farmyard manure 10 tons .	44,100
(2) Poudrette 10 tons	56,530
(3) Sewage effluent 21 waterings	55,330

These are still good crops, considerably above the average.

It might be considered that sewage is an unsuitable application for a crop which is intended to be eaten in the raw condition by horses and cattle. So it would be, I think, if the crop were sown on the bed system; where the stems of the plant would be in contact with the sewage liquid itself. If the ridge and furrow method is used, I do not think serious objection can be taken to the employment of sewage to irrigate the crop, as then the liquid never touches any part of the plant which would normally be cut. The trailing Quetta variety of lucerne should, however, not be grown. Another safeguard in the present case is the fact that the material used is septic tank effluent and not raw sewage. Few people, now-a-days, would, I think, seriously suggest putting raw sewage on black soil, and its advisability is doubtful anywhere. When it has passed through the septic tank process, most of the objections which could be taken against it either from a sanitary or an agricultural point of view seem to have disappeared.

Lucerne has, however, been grown at Karachi under application of raw sewage without any special treatment, being simply pumped from the sewers on to the land. Under this treatment very extraordinary yields have been obtained. Lucerne has, in fact, given thirty cuttings per annum, each cutting weighing from 4,000 to 6,000 pounds of green fodder. This gives a total yield per annum of from 120,000 pounds to 180,000 pounds of green fodder per acre.

*Inoculation of Soil for Lucerne.*—At this stage it may be well to refer to the value of inoculating the soil with the bacteria required to form the root nodules which enable the plant to fix and utilise atmospheric nitrogen. With most leguminous crops in general cultivation the attempt to increase yields by inoculation has not been greatly successful in practice, but with lucerne introduced into new localities it seems often to be almost essential in order at least to obtain a supply of bacteria in the soil which have accommodated themselves to growing on the lucerne roots. There are many cases where a crop of lucerne has been a failure when first planted, the plants not being vigorous and ultimately refusing to yield, but where a second crop on the same land has given excellent results.

The experience at Surat is to the point in this case. In 1905 to 1907 an experiment was made comparing two plots, both sown on the ridge and furrow system, one sown in October 1905 with inoculated, and the other at the same time with non-inoculated seed. Nitro-bacterine prepared for lucerne was, I believe, used for inoculation. The results are shown in the yields for 1906-07 when the inoculated plots gave a yield per acre of 30,668 and

28,164 pounds respectively, or an average of 29,416 pounds, while the non-inoculated plots gave 22,056 and 23,148 pounds per acre respectively or an average of 22,602 pounds. I have not the yields in the year following, but after this a note is made that inoculation has increased the yield by 25 per cent. and more than doubled the *nett* profit.

This is in accordance with what has been almost universal experience elsewhere, for in various parts of the United States, Canada, Scotland, and Australia inoculation has very materially increased the chance of obtaining a successful stand of lucerne in land where the crop has not been grown before,—especially when used in conjunction with lime at the rate of 1,500 pounds of lime per acre. In New York\* without either lime or inoculation the chance of a successful and profitable crop was one in five; using lime only at the above rate, it was two in five; using inoculation alone it was three in five; while using both lime and inoculation a successful crop was obtained in four out of every five trials. In Canada† inoculation was found not only to increase the yield but also to give a fodder richer in proteids. In North Dakota it would appear that upland medium loam soils absolutely required inoculation if lucerne is to be grown successfully,‡ and in Scotland§ inoculation was successful and as good as a dressing of nitrate of soda.

After many attempts to ascertain the best method of carrying out the inoculation, all authorities are agreed that the most effective plan is to apply 300 pounds per acre of soil of similar texture from a lucerne field in which the crop is already growing vigorously, before sowing the seed. All authorities are agreed that this is better than any of the commercial cultures on the market. In Australia¶ the value of different methods of inoculation was in the following order, the first being the best (1) mixing the soil with soil of similar texture and composition from a successful lucerne field, (2) watering the soil with the washings of a good lucerne soil, after germination of the seed, (3) watering the soil similarly before sowing the seed, (4) mixing with soil of different texture and composition from a successful lucerne field, (5) inoculation of seed with the bacteria from lucerne root nodules. Addition of lime to the soil increased the nodules on the lucerne roots if inoculation was practised but not otherwise. Results also pointing to the fact that soil is better than any culture have also been reported from Canada || and Nebraska \*\* among other places.

Wherever there is any difficulty in obtaining a stand of lucerne and there is no waterlogging or other adequate cause to account for it, it appears that it would be wise to mix the soil of the field with 300 pounds per acre of soil from a good lucerne field of similar texture just before sowing. It is possible that the omission of this may have been the cause of failure in some places,—and that its introduction in others might considerably increase the yield of crop obtained here in Western India.

\* New York, State Agricultural Station Bulletin No. 313 (1909). See also U. S. Farmers' Bulletin No. 374 (1909).

† Shutt—Canada Experiment Farms Report, 1909.

‡ Waldron—N. Dakota Agricultural Experiment Station Report (sub-station), 1908

§ Wright—West of Scotland Agricultural College Report, Vol. X (1911).

¶ Donnan—Agricultural Gazette, New South Wales, Vol. XXIII (1913), page 953.

|| Saunders, &c.—Canada Experiment Farms Reports, 1910.

\*\* Pugsley—Nebraska Agricultural Station Bulletin No. 136 (1912).

*Watering.*—As the provision of the large amount of water required by lucerne is the most expensive part of the cultivation of this crop, it becomes of considerable importance to ascertain the amount which is absolutely necessary to obtain the best results. The usual method employed in Western India is to irrigate heavily and very frequently. As already stated, in the bed system of cultivation as usually adopted, lucerne is irrigated every ten days in the cold weather and during breaks in the monsoon, and every six to eight days in the hot weather according to the character of the soil. At Sangamner, for instance, in planting lucerne the field is irrigated on the day of broad-casting. The second watering takes place on the fourth day, the third one is given six days later, and others every eighth or tenth day. In summer the land is irrigated every sixth day.\*

In the ridge and furrow system, Mollison recommends even more frequent watering,—that is to say, every eighth day in the cold season, and every sixth day in the hot weather on medium soil, and even more frequently if the soil be light.

Very few attempts have been made in Western India to measure the actual amount of water used. But some results of interest were obtained at Surat.† It was there found that lucerne grown on thin black soil in beds or on ridges requires irrigation water equal to five inches of rainfall for the first watering a month or a month and a half after the rains are over, and each subsequent watering is equal to between two to three and a half inches of rainfall. If irrigation takes place at intervals of thirty days, water equal to three inches of rainfall is required each time, and if after intervals of fifteen days, water equal to two and a half inches is needed on each occasion. As the season goes on and the temperature rises, an increase of water equal to one inch of rainfall is needed at each application. It was also found that irrigation less frequently than once in fifteen days led to considerable decrease in yield. Thus with lucerne planted in October 1904, the yields in 1906-07 were—

Plot irrigated every fifteen days.—24,339 pounds per acre.

Plot irrigated every thirty days.—18,289 pounds per acre.

The actual amount of water given in the year at Surat in 1909-10 in fourteen waterings was 802,349 gallons per acre or 35.66 inches of rain. The rainfall was 53.31 inches, almost all in four months. But this shows that no less than 88.97 inches of water was put on the soil in one year. This is, of course, extremely excessive, largely owing to the rainfall being so badly distributed, leading to enormous excess of water from June to September with a drought during the rest of the year.

The actual amount of irrigation water required in most parts of Western India is dependent rather on the duration of the rainfall than on its amount. And thus for eight months dry weather almost without rain,—a condition which prevails over much of our area—35.66 inches were given or water equivalent to nearly 4½ inches of rain per month. I do not know of any other accurate measurements of the quantity used in our areas, but in some parts of America where irrigation water is very expensive, the quantity used under temperature conditions not widely different from

\* Mirza—*loc. cit.*

† Report, Surat Agricultural Station, 1906-07.

ours is a little less. First class crops are obtained in California (with only nine to fifteen inches of rainfall and with a long dry hot summer) with irrigation equal to  $27\frac{1}{2}$  to 28 inches of rainfall, and in Montana with only  $8\frac{1}{2}$  inches of rain, the following yields of lucerne hay were obtained with different amounts of irrigation water.\*

Amount of irrigation water.	Yield of hay.
Inches.	tons.
None.	1.95
6	4.61
12	4.42
18	3.75
24	6.35
30	7.20
36	7.68

This rather indicates that if the amount of water is insufficient a little more will do harm, and only when the amount is equal to over 24 inches of rain is a really satisfactory return obtained. If we take it that this irrigation is spread over 8 months (there is no record in the matter) it means that in these regions of America it is found necessary to add 3.75 to 4.25 inches of water per month, or (as already noted) a little less than we use.

With regard to the frequency with which irrigation must be given to the crop no rule can be given, and judgment must be made by the condition of the crop. When the supply of water is insufficient the leaves become darker and duller in colour and begin to droop, and water must then be applied or serious injury may result. Or a handful of soil six inches or so below the surface may be taken and compressed in the hand: if it retains its ball-like shape after the pressure has been removed, the soil is moist enough, but if it falls apart readily, it is too dry.† These are, however, crude tests and very careful watching will be required whenever lucerne is planted under new conditions.

#### *Cutting the Crop.*

Planted as suggested here in October, lucerne will be ready to give a crop, under favourable conditions, two months later. It is probable that the first growth will be somewhat uneven, some being cut too immature and some a little beyond the best stage, but afterwards it will tend to get more equal in growth.

The stage at which it is best to cut lucerne has been a matter of many investigations, but of few in India. Here it is usually considered that it is in the right stage when about one quarter of the plants are in bloom, and this is probably, on the whole, a good rule. If cut too soon, it is usually watery: if cut too late, there is a possibility of harm to the stock. If cut too late, it has sometimes been found that the following growth is not so vigorous as otherwise.

\* See Fortier—U. S. Farmers' Bulletin, No. 373 (1909).

† These tests are given by Fortier, *loc. cit.*

Immediately on being cut, growth begins again, and crops are obtained from the same plants many times. "In the young plant, springing from the crown of the root, there is a simple basal stalk which gives rise to a number of low branches ascending directly from the ground and forming a small compact tuft. But when a plant is cut or eaten off, the stalk dies down to the very base, and produces buds from the upper part of the crown of the root, forming new stems in a dense cluster.\*" As a result of this manner of growth, lucerne cannot stand close pasturing as well as many other plants.

The number of cuttings, which can be obtained with a full water supply, will vary with the temperature and other climatic conditions. In the irrigated regions of the United States, nine cuttings in a year is considered a very large, and three to five perhaps an average number. Here in Western India, a well planted vigorous crop of lucerne should always give seven or eight cuttings, and many give up to twelve under very high manuring or sewage effluent. The actual results at each cutting under this last treatment at Manjri are shown in the following table. The seed was sown on May 8th, and the first cutting was obtained on July 19th.

Cuttings.	Sewage † septic effluent. Pounds of green lucerne.	Farm yard manure (20 tons) and canal water. Pounds of green lucerne.	Pondrette (30 tons) and canal water. Pounds of green lucerne.
July 19th	4,564	3,472	6,188
August 7th	9,576	8,036	12,096
September 3rd	7,364	6,440	8,848
September 30th	7,952	7,980	9,940
October 24th	6,720	7,168	8,232
November 21st	5,964	6,272	8,260
December 25th	8,680	8,064	9,884
January 30th	13,992	8,680	10,248
March 3rd	12,152	6,776	8,484
March 23rd	9,520	5,320	6,020
April 14th	8,652	4,172	5,180
May 2nd	7,952	2,240	2,800
Total	102,088	74,620	96,180

Thus with the most vigorous growth that we can produce under our conditions, cuttings can be obtained with intervals of from eighteen to thirty-five days according to the time of year, and apparently chiefly according to the temperature.

\* Thompson—Agricultural Journal of India, Vol. IV, page 321.

† Poona Experiment Farm Report, 1900-01.

Under more normal conditions using ordinary amounts of manure and canal water and planting at the beginning of June, lucerne in Poona gives eight cuttings before the end of the following March. The following are figures for each cutting of such a crop at the Government Dairy Farm, Poona, the crop being only a poor one.

	Pounds of green lucerne.
1st cutting.	3,509
2nd "	4,236
3rd "	4,891
4th "	2,891
5th "	3,327
6th "	3,364
7th "	3,545
8th "	2,909
	Total 28,672

This gives an average interval for the first year of the plants' life of under thirty days.\*

These figures give an idea of the yield which is usually obtainable in first year lucerne in Western India. The amount depends more than with most crops on the conditions being exactly the best. At its best, in ordinary practice, lucerne will give over 80,000 pounds per acre of green fodder in the first year. Mollison quotes 83,793 pounds per acre as having been obtained at Poona in 1892-93.† This is far larger than is usual and was obtained after sugar-cane heavily manured. The average return lies, however, between 30,000 and 40,000 pounds per acre of green fodder. Actual returns on plots manured in a normal fashion at Poona or Manjri are as follows :—

1892-93	27,000 lbs. to 36,700 lbs. green fodder per acre.
1896-97	28,700 „ green fodder per acre.
1904-05	27,900 „ to 39,000 lbs. green fodder per acre.
1910-11	32,400 „ green fodder per acre.
1912-13	52,800 „ „ „

These figures give an average at Poona for first year lucerne of little less than 36,000 pounds of green fodder per acre.

At other places in Western India where lucerne has been well and successfully grown, the yields are not widely different. At Surat in 1906-07, an average yield of 29,400 pounds of green fodder were obtained from lucerne six months old at the commencement of the experiment, and this represents about the amount which one may expect to obtain.

The yield in the second year is often considerably lower than the first however well manured the crop may be. With the very highly manured

\* Dairy Farm Report, Poona, 1905-06.

† Text Book of Indian Agriculture, Vol. III, page 283.

lucerne previously referred to (page 91) the relative amounts in the first and second year were as follows:—

	Green fodder per acre.	
	1st year.	2nd year.
	lbs.	lbs.
Sewage septic effluent	102,088	55,330
Farmyard manure	74,620	44,100
Poudrette	96,180	56,530

Under more ordinary conditions of cultivation, Mollison\* gives the following results at Poona as being the best he had had:—

1st year (1892-93)	83,793 lbs. green fodder per acre.
2nd year (1893-94)	31,816       "       "

This falling off is, however, excessive, and is perhaps due to the very large yield in the first year, which could not be maintained. In experiments at Manjri † with various kinds of manure, an average over all plots gave—

1st year	23,550 lbs. green fodder per acre.
2nd year	21,151       "       "

This shows a loss of about 10 per cent. in the second year's crop, and even this is more than is sometimes obtained. A very fair idea of the relative results in the different years of growth can be obtained from the following figures, being the average of areas under the ridge and furrow, and bed systems.

	Yield of green fodder lbs.
1910-11 ‡	17,092
1911-12	28,480
1912-13	29,310
1913-14	12,567

Here we have a case where the second year gives at least equal returns to the first, and this is probably obtainable generally if the cultivation is good, and if the soil is fairly free from weeds, and if the manuring at first has not been excessive. From the third year here deterioration is very rapid, and it may usually be taken that the crop will rarely last longer than four years in a profitable condition.

This has been the experience both at Poona and at Surat. At the latter place it has been stated that "four years seem to be the maximum period that a plantation of lucerne, when cultivated as an irrigated crop in deep black cotton soil, can be maintained."§ It is not that the plants die, but the cultivation of this crop costs so much money for irrigation that it ceases to pay.

#### *Lucerne as a mixed crop.*

In Western India, lucerne is practically always grown alone, and experiments so far indicate that this is the best plan. A few years ago, largely owing to the devastation caused by a fungus disease (of which more later) Mollison suggested that any gaps in the lucerne should be filled with sets of

\* *Loc. cit.*

† Manjri Agricultural Station Report, 1904-05.

‡ October to March only. Agricultural College Farm Report, 1913-14.

§ Surat Agricultural Station Report, 1907-08.



guinea grass. He showed that there was no difficulty in doing this, and the mixed fodder could also be reaped and used without difficulty. His hope, however, was that the presence of the guinea grass would conduce to the healthiness of the lucerne.

In making a regular mixed crop he first planted lucerne on ridges, twenty-two inches apart, and got it well-established. Then he put in guinea grass sets in the ridge, eighteen inches apart in the lucerne. At first the mixed crop gave a heavier yield by about 28 per cent. on the first cutting, and in the following year the mixed crop still gave an increase in the outturn of nearly 15 per cent. while a still greater difference in favour of the mixed crop was shown in the succeeding seasons.<sup>6</sup>

In spite of these increased yields, the method never became popular, and with the disappearance of the fungus disease mentioned, it was abandoned and the crops grown separately. It is well worth putting on record, however, that the mixture grows well, and without difficulty, and that guinea grass is an excellent crop to patch up a field of lucerne in which gaps occur due to disease or other causes.

I know only one attempt to sow lucerne among another crops in Western India, and that is at Dohad, where the seed was broadcasted among rice, and thus sown, gave a yield of 7,90½ pounds of green fodder.† The attempt is, however, so new, that no conclusion as to its feasibility or profit can yet be drawn. So far as the experiment has gone, however, the crop seems inferior to berseem for this purpose.

#### *Lucerne growing in the Konkan.*

In the regions with very heavy monsoon rain (usually about one hundred inches per annum), the method of cultivation given will not apply for the crop is not able to stand the rainy season and dies off in that part of the year. But in view of the fact that the Konkan cattle are very poor, that fodder in many parts is insufficient, particularly in the South Konkan, it has been suggested that even there there is a considerable field for the cultivation of lucerne. Experiments made at Ratnagiri‡ indicate that during the remainder of the year the crop grows luxuriantly and well, and it has been suggested that wherever irrigation facilities are available, its growing should be considered. It has, in fact, already become a regular practice in the northern part of the Thana District from which the lucerne is sent green to the Bombay market.§

The crop should be sown immediately after the harvesting of the *kharij* rice crop, that is to say, early in October or November, in the same manner as already described in the Deccan. Watering will have to be more frequent than on the Deccan in the cold weather on account of the higher temperature. The crop, however, has been found to yield four or five cuttings before the setting in of the monsoon, and to leave the land in good condition for the following rice crop.¶

#### *Enemies of lucerne.*

It must be recognised that in Western India, lucerne is not an easy crop to grow. It requires intensive cultivation, and very little neglect will

\* See Poona Farm Reports, 1893-94, 1894-95, 1896-97 and 1897-98.

† Dohad Agricultural Station Report, 1913-14.

‡ Report, Ratnagiri Agricultural Station, 1913-14.

§ Private communication from Mr. K. V. Joshi, B. Ag.

¶ Bombay Agricultural Leaflet No. 11 of 1915.

cause it either to die out through weeds, or through dodder, to disappear through root disease, or to be seriously injured by aphides. So much is this the case that in the early history of the crop in the Deccan Mollison was inclined to consider it as doomed to die out, as there had been little success in combating the various pests.\*

*Weeds.*—Of these enemies the first and perhaps the most important are the weeds, and more especially the deep rooted grasses like *hariali* (*Cynodon dactylon*), or *kunda* (*Saccharum spontaneum*) and *lovala* (*Cyperus rotundus*). It is those weeds that seem to make long continued cultivation of lucerne on one site impossible, and unless absolutely thorough cultivation of the land and removal of the root stocks is carried out before planting, it will be smothered long before the plot is old. These and similar grasses form the worst enemies not only here but everywhere where lucerne is grown.

It is folly, however, to sow lucerne in foul land, and it would be far better to keep the land fallow for a year and in the meantime cultivate the land thoroughly, continually, and deeply and clear away the root stocks. Then the land can be sown, and if planted on the ridge and furrow system all grasses except those in the ridges can easily be removed by hoeing, provided the hoeing is regular and frequent. If, in spite of all this, the weeds get a hold, it is an evidence that the land was planted foul, and the only thing to do is to plough up the land, clean it, and plant again.

*Dodder.*—One of the worst pests of lucerne in most countries where it is grown is the parasite known as dodder. It has not spread largely in Western India as yet, but is found in several of the districts and is a sufficiently serious menace to make it a matter of important consideration. It is known as *ninoli* in the Thana district where it is specially prevalent, and as *ambarvel* in the Poona district. Perhaps the greatest danger is that it is not recognised as a dangerous pest,† and the greatest safeguard is the fact that very little seed is produced and sold from the districts in which it is prevalent.

Dodder is a parasitic plant, whose seeds germinate along with the lucerne seed in the ground, and produce young thin climbing stems which climb round the stem of the lucerne. They quickly lose all connection with the ground, and then feed entirely on the lucerne plant, twining round it until it is killed. The dodder plants flower about the same time as the crop, and its seeds, though much smaller than those of the lucerne, get mixed with the latter, and are carried wherever the seed is carried and planted. There is, however, another danger in places where lucerne infested dodder seed has been introduced, namely, that the pest grows quite well on a number of other plants, and of course these may become centres of infection. Patwardhan notes having found it in the Thana district on a long list of plants among which are *Euphorbia verifolia*, *asan* (*Bridelia retusa*), *ain* (*Terminalia tomentosa*), *babul* (*Acacia arabica*), *jambul* (*Eugenia jambolana*), *wangi* (*Solanum melongena*) and *gavat* (*Andropogon annulatus*).

As already stated, the pest is not common in Poona and seems as yet to be unknown in many other parts of the Deccan. Mirza † states that he failed to find it in the neighbourhood of Sangamner.

\* Report, Poona Agricultural Station, 1894-95.

† See Patwardhan—Agricultural Journal Ind., Vol. IV, page 857.

‡ Poona Agricultural College Magazine, Vol. VI, page 180.

The only sure method of preventing dodder is to use pure seed and a guarantee of the freedom from the pest of the field where the seed was collected should be exacted from the seller of the seed. Lucerne seed is dear, and this can well be done. As a rule, lucerne seed from the Deccan is fairly safe; that from the Thana district is dangerous. Quetta seed should not be used without great care on this account. The seed can, however, be easily detected; it is much smaller than the lucerne seed and is nearly round in shape. At the time of planting all neighbouring hedges and trees should be carefully examined for the twining stems of dodder, and it should be destroyed remorselessly as far as possible.

If dodder appears here and there in small patches, the affected lucerne should be pulled up together with the pest and burned. If a large area is attacked, the whole should be ploughed up provided the pest is not in flower; if in flower, the whole should be cut, and burnt, and the roots then ploughed into the land.\* When a field is ploughed up on account of dodder, it should be planted with a crop not subject to this pest, and not with a leguminous plant, for at least two years.

*Rats as a Lucerne pest.*—In the United States rats (gophers) have been one of the serious menaces of lucerne cultivation, especially in the State of Kansas, and in the early days of lucerne cultivation in the Deccan they were also found to do much harm by gnawing and biting the roots.† It is difficult to say what should be done in such a case. The most usual method abroad is to put poisoned baits (sweet potato poisoned with kerosene or arsenic) in the rat holes. But here the best results have been obtained by fumigation of the holes with charcoal and sulphur fumes. Main‡ has described his practice as follows;—

“In practice it is usual to find that several holes are connected with one another by burrows in all directions, and it is necessary to stop up all holes before pumping in the sulphur fumes. The machine, a white-ant exterminator, is then worked for about three minutes. For this purpose one tola of sulphur powder per hole is required and about 60 to 80 holes can be fumigated in a day by one party consisting of two trained coolies, for a total cost of less than one rupee in sandy soil. The items of daily cost were as follows:—

	Rs. a. p.
Wages of two coolies at 5 annas	0 10 0
Cost of 1½ lbs. of sulphur	0 3 0
Cost of charcoal	0 1 6
	0 14 6

It was feared that fumigation would prove difficult in black soil where large cracks extend in every direction, but it has been found practicable to operate on those soils if an extra coolie be employed to assist in scraping loose soil over the cracks. In this way it was found that the sulphur fumes spread through an area varying from one-tenth to one half of a *guntha*§

\*Bombay Agricultural Leaflet No. 12 of 1915.

† Poona Agricultural Experiment Farm Report, 1896-97.

‡ Poona Agricultural College Magazine, Vol. VII (1915), page 79.

§ One *guntha* = one fortieth of an acre.

depending on the length and width of the fissures, and for this purpose one and a half to two tolas of sulphur were used, and the time required for one such operation varied from five to seven minutes."

A white-ant exterminator is an instrument containing a vessel in which charcoal and sulphur are burnt together, and flexible wire tube and pump for discharging the fumes into the holes. As imported it costs about Rs. 70 but an equally efficient instrument can no doubt be made locally at a much lower cost.

*Insect pests.*—Though a number of caterpillars and other insects have been noted on attacking lucerne, there are only two serious insect pests in Western India, the lucerne aphis and the lucerne caterpillar (*Laphygma exiqua*). The former of these is exceedingly serious and may materially affect the success of the cultivation. I am much indebted to Mr. B. S. Kasargode for information regarding these pests, and the substance of what follows is from an account kindly furnished by him.

*Lucerne aphis.*—The aphis which forms the most serious difficulty in Western India has been identified as *Chaetophorus maculatus* by Buckton in 1900.\* His samples came from Jodhpur, but the same insect prevails over all the lucerne growing areas. It has not been observed on other plants beside lucerne. It is a minute yellowish insect, with darker spots on the back and these spots serve to distinguish it from many other plant lice found on other crops. As among most other species of aphids, by far the larger proportion of the insects are wingless, and are viviparous; winged forms, male and female, and eggs, are only produced in smaller numbers.

Innumerable viviparous insects are, during an attack, seen crowding on the undersides of the leaves and tender shoots of the lucerne, and these suck the sap out by means of a thin beak. This not only hinders the progress of the plants, but very often completely kills them. The attack commences in the early weeks of March each year, and continues to the end of the hot weather. It is at its height in April, and it decreases and finally disappears in June when the monsoon commences. During the course of the attack a large number of winged individuals are produced viviparously, and as these can readily fly, they rapidly establish new centres of infection on healthy plants, until by the end of April almost all the plants in a field are attacked. The enormously rapid increase of aphis is mainly due to the viviparous mode of reproduction among these insects.

The seriousness of this pest is thoroughly recognised by the lucerne cultivators of Western India. Mollison noted in 1893 that unless it is planted in June, or in October to December, it is very liable to aphis attack; in 1894, he stated that aphis completely spoilt the crop in the hot weather, and only disappeared with heavy continuous rain. No remedy which he tried seemed to do much good. Since that time the complaints from this source have been annual, and probably more inquiries are made about this pest than about almost anything in connection with lucerne.

The following method devised by Kasargode† for dealing with the pest has been very successful, and I give it in his own words "The best and cheapest means of checking an attack depends upon detecting aphis when

\* Indian Museum Notes, Vol. IV (1900), page 377.

† Private communication to the author.

the attack commences. This it is sure to do in the last week of February or the first week of March. The crop should then be cut close to the ground even though it may not be ready for cutting. The field should then be flooded immediately and thoroughly, and the water not allowed to sink in, but allowed to run out of the fields. Our experience has shown that this can be easily managed in the case of lucerne planted on ridges and not in beds. If a sharp sickle is used for cutting the lucerne, very few aphids are dislodged, and such as are dislodged are carried away by the current of water through the field. If the field is not flooded immediately after a cutting, the dislodged aphids climb on to the young tender shoots which spring up very quickly after every cutting, and kill these off. The plants in consequence get weaker and weaker at each cutting.

"If the aphid is recognised too late a safer plan would be to spray the crop thoroughly with any contact poison like incosopol or crude-oil emulsion. This will cost from Rs. 3 to Rs. 4 per acre.

"Living among the plant lice (aphids) are always seen a number of round ladybird beetles. The mature as well as the immature forms of these very common beetles are found steadily feeding on aphids and are therefore very beneficial insects. Spraying the plants when the immature stages are passing into the mature beetles may kill them, and the spraying may therefore be delayed a little until at least the majority of them have got wings and are able to fly."

According to Mirza,\* the remedies practised by the cultivators in parts of the Ahmednagar district are as follows:—

- (1) Some farmers give *karanj* cake (cake of *Pongamia glabra* seed) to the land affected in order to destroy aphids, but this is not a very successful remedy. It is practised when the lucerne is only slightly attacked. If such be the case, it is apparently successful.
- (2) When lucerne is seriously attacked by aphids, watering is stopped and after fifteen days the lucerne is cut to the ground and the fodder is removed. Sometimes bullocks are grazed on the land without cutting the lucerne. Then the field is left without any operation for about a week and then irrigated. This is the most general method practised. By this method, about two cuttings are lost.
- (3) Some of the farmers, who do not wish to lose lucerne produce for about a month and a half, cut lucerne close to the ground and then irrigate the land, keeping in the main water channel some branches of *sher* (*Euphorbia tiracalli*). Very few farmers practise this.
- (4) If there be heavy rains, the aphids are destroyed. "Almost all the farmers practise the second method which is better than any of the other three..... No spraying has been practised up-to-now."

*Lucerne Caterpillar*†.—"The second important insect attacking lucerne is a moth *Laphygma* (*Caradrina*) *exigua*, the caterpillars of which appear suddenly in large swarms. It is not an annual visitor, but when it does appear it is always suddenly and in large swarms. These caterpillars have been observed to feed on other leguminous plants, and on indigo the insects are reported to be a bad pest. They can also feed on maize and cotton. The

\* Poona Agricultural College Magazine, Vol. VI, Page 180.

† Private communication from R. S. Kasargode.

moths are medium sized insects with grey wings, and appear soon after the end of the cold weather, and lay large numbers of eggs in masses covered with brown hairs on the top leaves of lucerne. The young caterpillars hatch within two days, and feed together in a webbing formed by tying the top leaves together. In about two more days they disperse to the neighbouring plants. The older caterpillars are very voracious and completely strip the plants of all their leaves. If sufficient food is not available, they march out of the field they have first attacked to a neighbouring field which they begin to strip in like manner. The caterpillars become full grown within two weeks of hatching.

"The caterpillars are slightly over an inch long, green with two black stripes on the sides of the body. They descend into the soil to pupate, coming out as moths less than a week later, and these produce the second brood of caterpillars. This larger and more serious brood may appear in April, and if proper precautions have not been taken during the first brood, it becomes very destructive to the crop. Further broods of the swarming type need not be expected.

"The webbing of the leaves is the first indication of the pest in a field of lucerne. If it is noticed within two or three days of the laying of the eggs, the large second brood may be checked easily by cutting the crop or feeding it off to cattle. As it more often happens that it is noticed too late and the caterpillars will have already dispersed from the webs, cutting of the crop is not always useful. The caterpillars are, however, in the habit of feeding in the morning and evenings, and hide in the soil during the heat of the day. A trench with sloping sides should first be dug around the affected patch; this need not be more than a foot deep, but the sides should be made smooth with a spade. When the trench is ready, a long heavy rope should be drawn across the affected patch, as often as possible in the mornings and evenings. The caterpillars are dislodged from the plants, and in trying to escape into neighbouring patches fall into the trench where they can be easily killed. A bag such as is used for the collection of rice grasshoppers can also be used instead of a rope. The caterpillars are easily caught in the bag and can be destroyed, those that drop from the plants will be caught in the trench.

"Inter culturing the crop after the apparent disappearance of the pest helps to turn the pupae out of the soil so that they can be destroyed by exposure, birds &c."

*Fungus Diseases of Lucerne.*—The diseases produced by fungus attacks on lucerne are many, but only one of them can be considered to have menaced seriously the industry in Western India, and this, a root fungus, has proved to be far less serious than was at one time thought likely.

In the early nineties, Mollison reported again and again that the area for instance, in the Poona district, was continually declining owing to the attacks of a peculiar root disease,\* and he thought that the crop was doomed in the neighbourhood, as no remedies which he had attempted to apply were in the least degree effective. The blight was described by Cunningham† in 1897, but he was unable to determine its exact character. His account of how it appeared at that time is, however, the best we have. He says that the disease was "described as gradually extending from one side of a field to the other, causing destruction of fully half of the roots as it did so, and giving rise to a proportionate diminution of the amount of fodder obtainable from

\* See Reports, Poona Experiment Farm, 1893-94 and 1894-95, particularly.

† Scientific Memoirs by Medical Officers of the Army in India, Part X (1897), p. 124.

the area. The crop was grown on soil 'full of manure' and supplied with irrigation water run along the course of furrows between the ridges on which the plants were situated... . The disease was confined to the bases of the stems and the origins of the larger roots. Where it was present the surface of the cortex was studded by great numbers of small prominences which in sections we found to be owing to the presence of minute sclerotia of irregularly rounded outline, and with diameters of 0.2 mm. and under. Detailed microscopical examination showed that the tissues were permeated by fungal mycelium, but that this was practically confined to the cortex, only here and there invading the bast and then being confined to the most superficial strata in it. The cells in the deeper part of the cortex were in many places crowded with masses of fungal elements, and at certain points dense strands of mycelial filaments forced their way out through the corky strata to give origin to the sclerotial bodies previously alluded to."

This disease has now been identified as due to *Rhizoctonia solani* or *Rhizoctonia destruens* (the former being the most common) by Shaw and Ajrekar\* a member of a group of fungi other members of which, such as *Rhizoctonia violaceae*, are found attacking lucerne in many parts of the world. It is certain that if it became really virulent it would soon put a stop to lucerne growing in any soil in which the fungus occurred in large amount. Luckily it has largely if not entirely disappeared from the Deccan, but has been found at Surat in badly drained places, where lucerne had been planted on an uneven field without previous arrangement for levelling and drainage. It did not, even there, affect the well planted areas.†

If the blight becomes serious, it will be most difficult to deal with. The sclerotia of the fungus live in the soil a long time. Shaw and Ajrekar (*loc. cit.*) found that they remained capable of germination for at least sixteen months, but not much longer than this, and suggested that by growing other crops for two years or more, the fungus might be starved out. Apart from this the only plan apparent at the present moment would be to sterilise the soil, either by heating (as in the *rab* process for rice seed beds), or by chemicals. In 1893 the use of soil treatment with copper sulphate solution did not, in Mollison's experiments, check the disease, and I think it is generally recognised that such treatment of the soil with chemicals is not possible as a practical method. This throws us back on the policy of long rotation free from lucerne on land which has proved to be infected, or of burning or heating the surface soil.

At the present moment this blight is not however a serious menace. If the ridge and furrow method of planting is adopted, and if waterlogging is most carefully avoided, it would appear that serious attack is not likely to take place in the immediate future.

*Spot disease of the Leaf.*—The only other disease noted as of any seriousness on lucerne in India‡ is the spot disease of the leaf (*Pseudopeziza mediaginis*), and this is only relatively of minor importance. Any time after the plant is beyond the seedling stage, but usually after it has had a year's growth, irregular brown spots appear on the upper side of the leaves. These grow till about one-sixteenth of an inch in diameter, and penetrate the leaf, the whole thickness becoming brown. The plants, as a whole, turn

\* Mem. Agric. Dept. Ind. Botanical Series, Vol. VII, No. 4 (1915).

† Surat Agricultural Station Report, 1912-13.

‡ See Thompson—Agricultural Journal Ind., Vol. IV, page 334 (1906).

yellow and the leaves drop off. Though the plants do not actually die, the yield is reduced, the value of the cuttings is decreased as they contain less leaves, and the leaves themselves are poorer in feeding value.\*

There is probably no real cure for the disease. It is said to be partially prevented by frequent and early cutting of the crop, and quick removal of the produce,† and beyond this, good manuring producing a vigorous growth is said to be effective. If the disease becomes really serious, there is nothing to be done but to plough up the land and sow in other places where the soil is free from the disease.

#### *Lucerne for Seed Production.*

As lucerne seed is dear, and as there is now a fairly regular demand for it, it will often pay to take a crop of seed from land under lucerne at least in the second or third year. The seed produced in the Deccan is usually worth at least Re. 1 per pound.

In growing seed, it is essential that during the growth of the seed no rain should be likely to be received, and irrigation should be withheld or given very sparingly from the time the lucerne is in flower. The object is to prevent too succulent a growth of stems and leaves and to avoid stimulating new growth from the crown, which greatly decreases the yield of seed. The yield per plant is also much increased if the plants are wide apart.

Usually a crop of seed is taken in the cold weather. Mollison recommends allowing it to grow about December or January. In the United Provinces it is the custom to leave it to grow up after cutting in February.‡ It grows rapidly and when the curious twisted pods have become yellow and mature the whole is cut, removed, dried, and beaten out. For growing seed, plants less than one year old should not be selected, as they give much weaker seed. In an experiment on the agricultural college farm, Poona, seed from Gujarat from plants one year old, and from the Deccan from plants two years old was compared in the yield which they gave. The results were as follows :—

Gujarat, one year old seed—16,187 lbs. green fodder per acre.

Deccan, two years' old seed—30,230 lbs.       "       "

There is also another reason why the plants should be fairly old, at least two years, before they are allowed to give a crop of seed. It is usually supposed that giving a seed crop exhausts the plants, and that they will not bear fodder so heavily afterwards or for so long a time. Taking a seed crop means sacrificing fodder cuttings for about three months.

The crop of seed per acre is usually about three maunds,§ or 240 pounds. The seed obtained, when fresh, should be plump and glossy, and mostly rich brown in colour, and free from admixture with weed seeds of any kind.

#### *Lucerne as a Fodder.*

As with other crops grown for fodder, lucerne may be cut at various stages of growth, and it is important to determine the best time, so as to gain the greatest amount of good fodder, do the least injury to the plant, and

\* New Jersey Experiment Station—quoted by Piper—*Forage Plants*, page 357.

† Osborne—*Journal of Agriculture*, South Australia, Vol. XVII (1913), page 294.

‡ United Provinces, Bulletin No. 6 (2nd edition), 1911.



get a product which will not injure the stock to which it is fed. In Western India, lucerne is never pastured to stock, except very occasionally when badly attacked by aphid or other insects, and so we have only to consider the best stage for cutting.

It is unfortunate that we cannot show, by analysis of Indian grown lucerne, the way in which the weight and composition of the crop varies according to the stage at which it is cut, especially as it varies enormously when conditions change.

According to experiments elsewhere (Kansas)\* the amount of moisture in the crop as cut, was as follows:—

	Per cent. moisture.
Cut when first flowers appear	74.6
Cut when half in bloom	69.7
Cut when in full bloom	64.2

As flowering proceeds the crop thus rapidly gets to contain far less water, and the digestibility of the protein also decreases from 90.2 to 81 per cent.† Generally speaking it is considered that the maximum yield of lucerne, and the largest amounts of valuable food will be obtained if it is cut when about half in flower. "It will be a more serious error to cut too early than to cut too late."‡

Perhaps some of the conclusions obtained at Utah§ with regard to the value of the crop cut at different stages are worth quoting.

These are—

1. The early cut lucerne contains the highest per cent. of proteids and fat, and the lowest per cent. of fibre. The former decreases regularly while the latter increases rapidly from early bloom to full maturity.

2. The proportion of leaves to stem is greatest at the early part of the flowering. At early flowering leaves form 42 per cent. of the total weight; at cutting in medium flower leaves form 40 per cent. and at cutting in late flower 37 per cent.

3. Leaves are much richer in proteids, fat, and nitrogen free extract than stems, and they contain much less fibre. On the average of all cuttings leaves contain  $1\frac{1}{2}$  times as much proteids as stems, 5 times as much fat, 35 per cent. more nitrogen-free extract, and stems contain  $2\frac{1}{2}$  times as much fibre as leaves.

4. The early cutting proved of higher feeding value, as follows. If we take the value of the crop cut at early flowering as 100, that cut at medium flowering would be 85, and that at late flowering 75.

When used as green fodder, which is almost always the case in Western India, it is, however, very important that it should not be cut too early because of its effect on some kinds of stock. Young lucerne, if eaten directly from the field, and without a considerable supply of dry fodder taken at the same time, is liable to cause tympanitis or hoven<sup>in</sup> in cattle or sheep, though

\* Kansas Agricultural Experiment Station, Bulletin No. 155 (1908).

† See Solerbaum—K. Landt Aka i. Handl. Tidski, Vol. XL (1901), page 364.

‡ Widdsoe.

§ Foster and Merrill—Bulletin No. 61, Utah Agricultural Experiment Station.

not in horses. The danger is, however, very remote with cut lucerne, especially if it is allowed to stand and slightly wither before being fed to the animals. About ten pounds per day can then be fed to a horse or a cow\* with very great advantage.

There has been a good deal of doubt here as to the value of lucerne for dairy cattle, but there seems nothing in it, provided the proportion used is not too great. The quantity suggested seems well within the margin. It is now used largely in small quantities, where available, in Western India by the *gaolis*, and its use will extend. Its chief purpose at present, however, is as horse food. It was first grown round the military cantonments with their large supply of military horses. Now it is used generally. Large quantities are despatched from Poona and also from the north of the Thana district to Bombay daily by train, and the traffic tends continually to increase. The value in Poona is about 120 pounds per rupee, but near large towns (Surat) it goes up to Rs. 12-8-0 per 1,000 lbs.

*Hay.*—Lucerne has not been made into hay in Western India on any scale, and in fact there seems an idea that it cannot well be made into hay. Mollison rather took this view, but the fact is that if it is carefully made, lucerne provides excellent hay. "It should be cut when beginning to flower, and allowed to dry before stacking. It should be handled as little and as carefully as possible, or the leaves which are the most nutritious part of the plant are shattered and lost. In hot countries it very rapidly dries; and when thoroughly cured, it may be made into stacks, and baled in the ordinary way. The whole process is extremely simple: but care must be taken to cure it well or heating takes place in the stacks or bales. The best lucerne hay is of a bright green colour, but its colour is readily changed to yellow or brown by the effect of rain or even dew, and by heating in the stack (Thompsonstone).

At present, and for a long time to come probably, lucerne will be used for other purposes than hay making. The demand for green fodder is so great that a valuable material like lucerne is not likely to be dried into hay during the long dry weather, and in the rains it is impossible to make hay, and silage would be much more likely. But even its extensive use for silage is not probable and in any case we have hardly any Indian experience in the matter. Though good silage was made at Ganeshkhind in 1909† yet the loss in weight (71·3 per cent.) was so great that this can hardly be taken as a fair example. Outside India, though quite useful for silage making, it is found to have its own difficulties, and needs chopping and very close packing to prevent a large amount of spoiling.

But lucerne is essentially a crop for cutting green and feeding direct to stock. For this it has no rival among leguminous crops over the greater part of Western India, and together with fodder *jowar* and maize would seem to be likely to go more near to solving the fodder problem in Western India than any other method yet suggested.

## XI. BERSEEM OR EGYPTIAN CLOVER AND OTHER CLOVERS.

Among the crops recently introduced into Western India, there is none that has more promise than berseem or Egyptian clover. Especially it is useful in the driest and hottest parts of the country, namely in Sind,—and

\* Thompsonstone—*loc cit.*

† Ganeshkhind Gardens Report, 1909-10.

the history of this crop during the last few years there.—when it was at first a very qualified success, but is now recognised as of very great value,—is a lesson in the successful introduction of a new crop.

It is well known as the chief fodder crop of Egypt, and one of the mainstays of agriculture in that country. As Fairchild\* remarks in an enthusiastic bulletin on the crop "It is the first crop planted after reclaiming the salt lands: it furnishes the green fodder for all the animals in the big towns: on it graze all the beef and milch cattle: the camels are fed upon it: the well kept donkeys get their portion of it, and even the poor *fellah* carries a bunch of it in his hand and seems to enjoy its sharp clover taste." And this enthusiasm seems to be shared by all who have had anything to do with Egyptian agriculture. Now there are one or two parts of India whose climate is closely similar to that of Egypt,—Sind and the Southern Punjab being the closest. These are also composed of land all but entirely under irrigation, and which depend for their water on the supply brought by a single big river. Evidently they form a country whose development is limited by the fodder supply, and in which, previously, a good leguminous fodder crop, capable of growing in the cold weather and giving a succession of crops, did not exist.

#### *Experiments with Berseem.*

Berseem,—a leguminous fodder crop with all these advantages—was introduced into Sind at Mirpurkhas in 1901, and from the first it gave good results in some places in the *rabi* season. When planted in September, and when water was available in abundance it remained on the ground till June, yielded 17,286 pounds of green fodder per acre and was readily eaten by stock.† Similar results were obtained in the following year, and it was furthermore discovered that it must not be planted later than September or the yield will decrease. Two years later 7½ tons of green berseem were obtained per acre,—but over much of the area where it was planted, the water supply was not reliable enough, and there was found to be too much salt in the land for the berseem to tolerate.‡ By 1909 it was considered by Henderson to have been conclusively proved that this crop grows very well in Sind, and he added that "it is a very valuable introduction and its extended cultivation is of the greatest importance on perennial canals. As a restorative crop none of the other pulses can be compared with it, and none except lucern give such a yield of good nutritive fodder." Besides this it had been found to grow on slightly salt land,—and (a very important matter) not to usurp the place of cotton, the money making crop in the Sind rotation.

From this moment it began to spread. It was found that in Sind a crop should be ready by November, and it gave hay which was considered by horse dealers in Bombay as only inferior in value to clover hay "It will probably be found" said Henderson§ at this stage, "that the fodder question in Sind can only be solved by cultivating berseem in the cold weather and by fodder *jowar* in the hot." It is now grown in many parts of Sind as well as near Mirpurkhas and the supply of berseem seed has been taken over by a joint stock company as a regular commercial proceeding.

\* U. S. Department of Agriculture, Bureau of Plant Industry, Bulletin No. 23 (1903).

† Report, Mirpurkhas Agricultural Station, 1904-05 and 1905-06.

‡ Henderson—Mirpurkhas Agricultural Station Reports, 1905-06, 1906-07 and 1908-09.

§ Henderson—Mirpurkhas Agricultural Station Report, 1910-11.

In the meantime equally good results have been obtained where the conditions are similar; further north in the Punjab,—at Lahore, Ferozepore, and other centres,\*—as well as at Nagpur where the conditions are much more like those of the Bombay Deccan.

In other parts of Western India its value is still problematical. Of course the conditions differ more widely than do those of Sind or the Punjab from the Egyptian surroundings to which berseem is accustomed, and some years must pass before we know whether it is going to take a vital place in our fodder supplies. On present information it seems at least doubtful how far it will grow, and how far it is likely to compete with lucerne under the conditions of the greater part of Western India. In the meantime the reports to hand are as follows. At Poona, as long ago as 1894 it was grown but Mollison reported that the seed came up, but only gave dwarf plants which made no progress: † I understand, however, that it was planted in the rains, and this accounts for the failure. One or two experiments in Poona since have not been very promising. In 1913-14 ‡ for example berseem was sown as a *rabi* crop. It gave its first cutting within two months, but did not do well after this, did not branch, and produced seeds early in the season. At Nadiad (Gujarat) § it was sown in November in 1912, gave good germination and two cuttings, yielding crops in the latter part of February (8,120 pounds per acre) and in the third week in April (2,464 pounds per acre), and giving a total yield of 10,600 pounds of green fodder per acre. It seemed to go off when the hot weather started. As the growing of this crop cost Rs. 185 per acre, it will hardly pay unless much better results than these can be obtained. At Dohad ¶ (Panch Mahals) the result of a similar trial was considered to be encouraging. The berseem was sown as soon as rice was harvested, that is to say, from October onwards. It gave 3½,451 pounds of green fodder per acre at a cost of Rs. 33 only, the value of the crop being Rs. 86. At Alibag || in the Konkan, it grew well and gave 15,280 pounds of fodder per acre in two cuttings under irrigation.

On the whole it may be said that its position in Sind and the Punjab, and probably also in parts of the Central Provinces, is now an assured one. In the remainder of Western India, there is enough promise to justify the continuance of experiments in all the centres above mentioned, and in others also. In attempting to describe the cultivation, I shall have to rely largely on Egyptian experience,\*\* as modified by reports by Henderson in Sind, and by Marriott †† and others in the Punjab,—and it is quite possible that ten years hence these methods will have to be very largely altered as a result of further experiment. It is the best, however, that we can do at present.

#### *Virtues of Berseem.*

The particular virtues which berseem is considered to possess in Egypt are (1) that its use prevents the diminution of the store of humus in the

\* See Marriott—Agricultural Journal Ind., Vol. X (1915), page 81.

† Poona Experimental Farm Report, 1894-95.

‡ Agricultural College Agricultural Station Report, 1913-14.

§ Nadiad Agricultural Station Report, 1912-13.

¶ Dohad Agricultural Station Report, 1913-14.

|| Alibag Agricultural Station Report, 1913-14.

\*\* Foaden and Fletcher—Text Book of Egyptian Agriculture, Vol. II, page 462.

†† Agricultural Journal of India, Vol. X (1915), page 81.

soil, (2) that it is particularly good for opening up the soil, (3) that it "possesses high manurial value for the crops which follow it," (4) it is the only food of the working and dairy animals belonging to the cultivators between December and June. The effect of this crop on the humus content of the soil is well illustrated by some figures given by Foaden.\* He determined the amount of nitrogen in the soil at various stages in the growth of a berseem crop, and found in two cases (A and B) percentages of nitrogen as follows :—

	A.	B.
Nitrogen in Soil—	p.c.	p.c.
(1) before sowing	·099	·101
(2) after first crop	·110	·116
(3) after second crop	·113	·111
(4) after third crop	·105	
(5) after fourth crop	·099	

The increase during the early part of the growth is very great indeed, but it disappears largely if the crop is allowed to mature completely. Apart from this it is considered that the roots contain about fifty-eight pounds of nitrogen per acre, and apart entirely from the crop being fed off, this will be retained in the soil.

#### *Rotations for Berseem.*

Berseem enters into cultivation in the ordinary rotation of crops. There is no need to give the rotations found successful in Egypt, as the following have been found useful and satisfactory by Henderson in Sind :—†

#### *I. Two years' Rotation.*

	1st Year.	2nd Year.
<i>Rabi</i> crop	Berseem ploughed in	Berseem allowed to seed.
<i>Kharif</i> crop	Cotton	<i>Bajri</i> or <i>Jowar</i> .

#### *II. Three years' Rotation.*

	1st Year.	2nd Year.	3rd Year.
<i>Rabi</i> crop	Berseem ploughed in	Berseem allowed to seed	Wheat.
<i>Kharif</i> crop	Cotton	Fodder <i>Jowar</i>	<i>Bajri</i> or <i>Jowar</i> .

\* United States Department, Bureau of Plant Ind., Bulletin No. 62.

† Mirpurkhas Agricultural Station Report, 1910-11.

If a farm is utilised purely or essentially for growing fodder, there seems little reason why the simple rotation of berseem and fodder *jowar* should not be continued for a long time, when perennial water is available.

#### *Cultivation.*

*Varieties.*—Of the varieties cultivated in Egypt (*Fahl*, *Saidi*, *Miscawi*, and *Khadrawi*) only *Miscawi* and *Khadrawi* need be considered in India.\* The type which has been chiefly experimented with is *Miscawi*. At Lahore, this grew tall, and luxuriant, and gave much green fodder. It needs much water and if it gets this, will give four or five cuttings and a crop of seed. *Khadrawi* needs more water but gives more cuttings.

*Cultivation.*—The method adopted in Lahore for cultivating the crop was to plough and prepare the land as for an ordinary irrigated *rabi* crop. No manure is needed. Forty pounds of seed per acre were sown broadcast in September. Two inches of irrigation water were put on the land, and the seed broadcasted in the water, when it germinates as the water dries. The land should be soaked in the evening of the day before sowing, and the seed sown at midday. In Egypt it has been found that early sowing gave a more rapid growth, but at that time there is more danger from surface caterpillars and cotton worm; late sowing, on the other hand, retards the growth of the crop. Two to three waterings are given before the first cuttings, which can be taken forty-five to eighty days after sowing, according to the climatic conditions which prevail during its growth. It is cut when fifteen to eighteen inches high, and should not be in need of water when cut, as it ought to begin to grow at once after the cutting. Hence it should be watered ten days before cutting, and cut again in thirty-five to forty days. If sown early it will give five to six cuttings. The early cuttings are very watery, and the later cuttings only are used in Egypt to make hay. The fifth cutting with early planted berseem or the fourth, with the crop planted later, is usually allowed to seed.

#### *Yields of Berseem.*

The actual yields from berseem in the Punjab and Sind where it is recognised as a success have varied very much. At Ferozepore it gave 34,977 pounds of green fodder per acre on good manured land in 1912-13. At Lahore, in 1913-14, it was sown early in October, and a cutting was ready by November 20th, the total yield for the season being 35,809 pounds per acre of green fodder. Another plot on the same farm gave 53,515 pounds of green fodder per acre in six cuttings, but this had grown a poor crop of berseem in the previous year. This suggests that one crop,—even a poor one—encourages in the soil the particular organism needed to inoculate the roots, and a second crop is likely to grow much better than the first. In this case the amount per acre obtained at each cutting was as follows:—

	lbs.
1st cutting.	4,978
2nd "	8,032
3rd "	12,784
4th "	13,940
5th "	10,912
6th "	2,870

\* Marriott—*loc. cit.*

At Multan the largest yield from any Punjab centre has been obtained, that is to say, 97,000 pounds of green fodder per acre on land heavily manured on November 1st, and even then the crop was retarded through frost in December. At Sukkur\* it gave three or four cuttings with eighty maunds or 6,400 pounds per cutting per acre,—or from twenty to twenty-five thousand pounds per acre for the year. At other centres in Sind, I cannot indicate the actual yield, for it has been nearly always used partially for pasturage or else the standing crop has been sold.

#### *Utilisation of Berseem.*

The utilisation of the berseem crop may be carried out in several ways. In the first place, stock may be tethered in berseem after the Egyptian fashion, and this method has been regularly adopted at Mirpurkhas (Sind). There all the farm stock have been tethered in the berseem from October to April, the work cattle only getting a few pounds of cotton seed per day beside. There is just a little danger when the stock are first put in among the luscious berseem herbage that they will get hoven, but this does not seem great if care is taken. In Egypt it is considered particularly liable to cause hoven when eaten while dew is on it in the early morning. It is moreover estimated that a bullock will require about two-thirds of an acre of berseem and a cow a little less to keep it in green fodder throughout the cold weather.

It is most likely, however, that the chief use of berseem here as in Egypt, will be for feeding green in the stable. For this it seems admirably adapted, and has already achieved a demand in the Sind and Punjab markets. At Mirpurkhas † it is sold in the bazar at eight annas per maund of eighty pounds and a single standing crop has fetched Rs. 10 to 12 per acre. At Sukkur a single cutting from an acre was sold for Rs. 20 in the standing condition, and even for Rs. 30 in the later part of the season. It has also been successfully made into hay.

Freshly cut berseem is very much more watery than lucerne, and an analysis, quoted by Fairchild, gave water—89.61 per cent., fibre—3.41 per cent., proteins—2.29 per cent. This fact must be taken into account in feeding berseem, and a correspondingly larger amount of berseem used than would be necessary with lucerne with its 70 per cent. of water.

#### *Utilisation of Berseem in Reclaiming Salt Lands.*

One of the purposes which berseem serves in Egypt is in the reclamation of land which contains salt. In all silty alluvial soils, where drainage is possible, salt is usually cleared from the land for agricultural purposes by means of bunding the land and then putting open drains or ditches outside the bunds to carry off the surplus water. The basins thus formed are then flooded with water, and as soon as the land is sufficiently freed from salt, coarse rice is grown, and sometimes the millet *sawan* (*Panicum crusgalli*) of which we have already spoken. When these have proved by their success that the salt is largely removed, then berseem follows as a cold weather irrigated crop. If it grows, then the land is fit to grow cotton, and probably any other crop which is likely to be put on. In this manner berseem serves a very useful purpose and has been considered as one of the most important

\* Sukkur Agricultural Station Report, 1911-12.

† Report, 1912-13 and 1911-12.

agents in the reclamation of such land.\* It has served an actually useful similar purpose in Sind, where Henderson has made considerable and successful reclamation experiments on Egyptian lines. †

#### *Berseem Seed.*

Berseem seed as imported from Egypt is usually very dirty, and a good average sample contains about seven per cent. of dirt. ‡ Weed seeds are common especially chicory and wild mustard, and also dodder. All these are very objectionable and a special warning in India has been issued about the first and the third of these.

*Dodder*, a parasitic plant whose characters have been already described under lucerne, is a very dangerous enemy, and all samples of seed should be carefully inspected for this, and all samples rejected which contain it. §

Chicory is also a dangerous weed, which tends to create scouring in animals, and though its amount in the growing crop appears to decrease after each cutting, yet it is a considerable danger—and the likelihood of its presence needs warning against. ¶ In the growing crop it should be rooted out without mercy.

Seed has still to be imported as the quantity grown even yet is hardly sufficient for extensive cultivation. It can be now obtained from the Sind Reclamation Co., Mirpurkhas, Sind, and costs about Rs. 16 per maund of eighty pounds.

#### *Enemies of Berseem.*

Two classes of insect pests appear to attack berseem in Egypt,—namely the surface caterpillars (*Agrotis segetum*) || and others, and the so-called cotton worm (*Prodenia litoralis*). Both of these are insects occurring very widely in the tropics, and the danger is considerable of their appearing as serious pests in India.

Both of them particularly attack early sown berseem, and are said to clear a field quickly if the attack is a bad one, and so make resowing necessary. The usual plan adopted in the case of an attack is to feed off, and water heavily, and at the same time clear weeds away, roll the damp ground, and if available, apply gas lime.

#### *General Conclusions.*

On the whole, for those particular climatic conditions which suit it, like Sind and the Punjab, berseem promises to be of exceedingly great value in India. Elsewhere, its value is still a matter for experiment. Under suitable conditions, however, it fills a gap in our available fodder crops, and forms a rapid growing fodder for the cold weather, giving repeated cuttings and heavy yields, provided abundant irrigation is available. The excellent effect on the fertility

\* See Means—United States Department of Agriculture, Yearbook, 1902.

† Daulatpur Reclamation Station Reports.

‡ Foaden and Fletcher—Text Book of Egyptian Agriculture, Vol. II, page 469.

§ See Agricultural Journal Ind., Vol. VIII (1913), page 306, and Vol. X (1915), page 85 (foot note).

¶ Brown—Agricultural Journal Ind., Vol. X (1915), page 402.

|| See Bonaparte—Journal Khed. Agric. Soc., Vol. IV (1902), page 224.



of the land should not be forgotten. It is usually planted at Mirpurkhas without manure, and yet in 1913-14 it was stated to have doubled "the fertility of the farm."

While, therefore, it is well not to be too sanguine as to the extent to which its cultivation will spread, the introduction of berseem does form a very important step in the development of the fodder resources of parts of India where they were very especially needed.

#### OTHER CLOVERS.

Other clovers cannot be said to have been successful in the plains of Western India. In the hill districts of Quetta, five thousand feet high, to the west of Sind, and usually included in Baluchistan such excellent results have been obtained with shaftal by Howard\* that a description of the methods they have adopted and the results obtained would appear to be useful.

#### SHAFTAL.

*Shaftal* or Persian clover (*Trifolium resupinatum*) is an important crop of the whole north-west frontier of India, and, for instance, forms one of the principal sources of fodder in the *rabi* season in the Peshawar and similarly situated valleys. In the plains it has proved of little use. It was grown experimentally in 1912-13 at the Poona Agricultural College under irrigation, and gave two cuttings amounting together to 3,575 pounds of green fodder per acre. It could not apparently stand the hot weather and died away. It is, apparently, unsuitable in fact for the semi-tropical conditions of sea-level or low elevation here, but seems likely to be of great value in the colder hill regions of the country. Under these conditions Howard stated that "it will yield four crops in one year, three of which can be utilised for fodder and the last either for seed or as green-manure. The plants set seed freely during the month of June so that there is no difficulty with regard to a fresh supply for sowing. No pests have been observed on this crop when properly grown and when regularly cut. If, however, it is over-watered and if it is not cut in time, the leaves are often attacked by a fungus, but this does not reappear on the foliage of the new growth unless it becomes over ripe."

The procedure recommended by Howard for its cultivation in the Quetta valley is as follows:—

The sprouted *shaftal* seed, at the rate of twenty pounds per acre mixed with an equal weight of dry earth, is sown in the irrigation water on the plots where it is to be grown about the latter half of August. The seeds root at once and as soon as possible a light covering of dry earth is applied. A second light watering is given as soon as the ground has dried.

A light cover crop of maize or jowar, previously sown, is useful to protect the *shaftal* seedlings from wind and sun. This is removed in the early part of September, and thereafter the *shaftal* crop grows alone. The surface of the ground should be kept cultivated and in such a condition as to form an earth mulch. Irrigation should not be excessive, but should be given whenever the change in colour to a darker green (already noted as occurring with lucerne) announces the need for water. The need for irrigation water is not great at Quetta until rapid growth takes place in the spring.

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\* Fruit Experiment Station, Quetta, Bulletin No. 5 (1915). Most of the data which follow are from his bulletin.

The crop only grows slowly during the cold weather, but then produces several cuts, generally three before it finally forms flowers and seed in June. This last crop is used either for green manure or for the collection of seed. The yield obtained by Howard on unmaured land was 60,000 pounds per acre in three cuts. This could probably be increased by manuring. It is important that the crop should be cut as soon as possible in the spring and as often as possible, as any delay in cutting tends to bring on rust and weakens the stand of plants.

The feeding value of *shaftal* has been well known on the north-west frontier for a long time. It can be used for dairy cows and buffaloes for which it is most suitable, and for horses, raules, and work cattle if only it is cut up and mixed with dry jowar or other similar fodder. Otherwise it is liable to cause hoven.

It cannot only be fed green, but it is also very suitable for making hay, considerably more so than lucerne. As the climate of Quetta is very dry, the formation of hay has to be done gradually in stages. "After cutting the *shaftal* is spread out to dry for a day or two when it is turned and allowed to dry for another day. When about half dry, it is collected into heaps and pressed down firmly so as to check the rate of drying. - Provided it is put into heaps just at the right stage, on the second day the fodder begins to get warm. At this point, the heaps are opened and the produce carried to the stack during which it dries considerably. Some little experience is needed in determining the stage at which to stack the fodder. If it is too dry, no slow after-fermentation takes place and it becomes too brittle for baling. If, on the other hand, it is stacked too damp, over-heating takes place and the final product moulds.....Two months in the stack is ample for the development of the proper colour and texture, after which the hay can be baled" (Howard).

The loss of weight in hay making was about seventy-six to eighty four per cent. in Quetta, according to the stage of ripeness of the crop. "A fair average would be twenty pounds of hay to one hundred pounds of green *shaftal*" (Howard). The hay has been uniformly considered to be excellent in the neighbourhood of Quetta.

Whether *shaftal* has any future in other parts of the Bombay Presidency cannot yet be stated. The climate on the plains or on the Deccan in the autumn and cold weather is evidently too hot for it to produce a good stand of plants. Some of the higher hill regions, such as Mahableshwar and similar hill sections of the Western Ghats, where irrigation is available, might be very suitable places for the trial of this crop. Wherever it is successful it will form a most valuable addition to the fodder resources of a class of country in India where these have been notoriously scanty.

#### SENJI.

*Senji (Melilotus alba or Melilotus indica)*.—This common leguminous weed in the Punjab, very similar to clover in character, is not infrequently sown in North India as a fodder crop. It occurs either as a white flowered plant (*Melilotus alba*) or a yellow flowered plant (*Melilotus indica*), and either one or the other is sown in October, and harvested in February or March. It is there said to be best grown mixed with other crops such as barley or oats. Both varieties are said to be of considerable value when fed green to milch cattle, but if allowed to ripen they are liable to cause colic

"They require rich and moist land such as the alluvial land in the beds of rivers, and should be irrigated."\* Under the name 'sweet clover' the white flowered variety is grown to a considerable extent in the United States and also in the warmer part of the temperate zones elsewhere, while the yellow flowered variety is also grown, though perhaps to a less extent, in both the southern United States and in Australia.

Several attempts have been made to introduce these as crops in various parts of Western India. In 1905-06 *Melilotus indica* was grown successfully in Sind (Mirpurkhas†). It yielded 6,933 pounds of green fodder, but was so obviously inferior to berseem as a cold weather fodder crop that no serious attempt has been made to grow it since. In 1909-10 *Melilotus alba* was grown at several centres in the Bombay Presidency. At Poona it was reported that the crop was stunted and sparse, and that after the first cutting it flowered and seeded. The fodder was unpleasant and smelt badly, and the cattle refused to touch it‡. This, I may remark, is always a difficulty at first with *Melilotus* fodder but animals soon get used to it. The crop proved a failure at Dharwar in the same season.§

On the whole there does not seem much promise for the utilisation of these clovers except in Sind, and there, berseem is so much better that they need hardly be considered.

## XII.—CHAVLI OR COWPEA.

While lucerne to a large extent (except in Sind) forms an excellent perennial leguminous crop, and berseem seems likely to give us a good annual *rabi* leguminous fodder at any rate in Sind, and perhaps elsewhere, other leguminous fodders are needed, especially (1) for growing (a) in the rains and (b) in the hot weather, and (2) for growing as rotations with the *jowars* and maize when berseem will not grow. Now in India we are particularly rich in pulse crops, and it would be surprising if some of these did not fill the need. I do not intend to consider here the growth of any of these crops when the primary object is the production of seed and that of fodder secondary, but only to try and give an account of experiments with them as fodder crops simply, especially considered as filling the purposes above suggested, and the methods which have been evolved as a result.

Of these the most important are probably *chavli* or cowpea (*Vigna catjang*) and *val* (*Dolichos lablab*) both of which appear to have a very considerable future in this direction.

*Chavli* is a crop which while well known to the people all over the country is not really extensively cultivated even for seed. It is curious to find a crop so little used here where it is at home, developing chiefly as a fodder crop in America and elsewhere to the extent which has been the case. Altogether in the Bombay Presidency its cultivation does not exceed about 25,000 acres annually, chiefly in the Kaira, Khandesh, Belgaum, Bijapur and Thana districts and most of this is as a subordinate crop with cereals

\* Meagher and Williams—Farm Manual, page 62.

† Report, Mirpurkhas Agricultural Station, 1905-06.

‡ Agricultural College Station, Poona, Report, 1909-10.

§ Report, Dharwar Agricultural Station, 1909-10.

where the conditions of rainfall and season are good enough. Unless the conditions of rainfall and soil are very favourable it does not succeed so well as *mug* or *udid* for that purpose. In Kaira district it is however regularly used as a mixed cultivation with *bajri* on light alluvial soils.\*

*Chavli* is a low growing, large leaved, climbing or twining pulse, with flowers which vary from pale blue to reddish purple inside and yellowish outside. The beans are long, and when the crop is ripening are easily seen in clusters of three to six above the level of the twining crop. The long straight pods are indented on each side so that each seed occupies a separate cell so to speak, and the bean is hence quite characteristic in appearance.

When a search began in Western India for suitable fodder crops more than twenty years ago, *chavli* early attracted attention and from the beginning gave good results at Poona in good deep soil in the rains, in the hot weather with irrigation, and, more doubtfully, as a rabi crop. In 1893, as a hot weather crop it gave 15,253 pounds per acre and was better than *val*. The waste in feeding was noticed to be very small, while during growth it had great power of smothering weeds.† As time went on the specific purposes for which *chavli* and *val* are suited became better defined: *chavli* grew best in the hot weather under irrigation, and in the rains on almost any soil but particularly on good deep land, but *val* was distinctly better as a crop after the end of the rains. Some yields obtained in Poona as a rains crop are shown as follows:—

Year.	Seed used per acre.	Yield (green) per acre.	Cost per acre.	Value per acre.
	lbs.	lbs.	Rs. a. p.	Rs. a. p.
1894	40	12,089	17 0 0	48 0 0
1895	48	7,346	13 8 0	29 8 0
1905	No record	6,981	40 0 0	No record

These may be taken as typical of the kind of return which may be expected in the greater part of the Bombay Presidency. In Sind, where the crop had been unknown, and where, of course, it must be grown under irrigation, it has had considerable success when sown in June and cut for the first time at the end of August. The actual results at Mirpurkhas have been as follows:—‡

Year.	Yield per acre.	Remarks.
	lbs.	
1910	18,000	Second cutting very poor.
1911	16,000	No second cutting.
1912	12,000	Two cuttings.

\* Mollison—Text Book of Agriculture, Vol. III, page 89.

† Report, Poona Experiment Farm, 1893-94.

‡ Reports, Mirpurkhas Agricultural Station, 1910-11, &c.

As a result, the conclusion was stated as follows in 1914 as regards Sind:—"The ideal pulse would give repeated cuttings of good fodder in the hot weather, and give a final cut for seed before being ploughed in for *rabi* crops. *Val* and *chavli* followed by soybean and velvet bean seem to be the most promising up to date." Results quite as good as those quoted have been obtained in other parts of Sind.\*

In view of this success, we will consider more in detail the most satisfactory conditions and methods of cultivation. Apparently almost any soil will suit *chavli*, but a good deep soil answers best especially if moderately light in texture. The seed should be drilled either in February for hot weather irrigated cultivation, or at the commencement of June, after the first rains have fallen, for cultivation in the rains. In either case the land must be prepared into a fairly fine tilth, and the seed drilled in rows at a distance of from twelve to eighteen inches apart or even wider. The growing plant spreads rapidly, and soon covers up the space between the rows. About thirty to forty pounds of seed per acre are needed in this method of cultivation.

There are a considerable number of varieties of *chavli* on the market varying much in colour or appearance, but little is known of their relative value for fodder purposes, and very few experiments have been made. In tests made at the Kirkee Dairy Farm in 1904, the small seeded varieties proved themselves much superior to others for fodder purposes,† but this is the only local record on the question of variety that I can find.

The crop takes about two and a half months or a little more to mature for cutting. Cutting should take place when the pods are well formed, but are still green, and the crop can be fed green or be allowed to dry into hay. Under favourable conditions the plants will sprout again and give a second crop of fodder, as is indicated in the above details given with regard to the crop in Sind. But as a rule the second crop so obtained is a very small one, and *chavli* as a fodder crop must stand or fall by the first cutting.

I have already said that the cutting of the crop should take place while the pods are still green. If the plants are left later than this the weight will be slightly increased, but the leaflets are inclined to fall off, and so the value of the material for fodder is reduced. With us *chavli* has always been cut by hand, but there is no difficulty in cutting the crop with an ordinary mower, and if a bunching attachment to lift the vines off the ground is added this method works perfectly.

If grown in the hot weather with irrigation, the crop is always fed green. At that time of the year green fodder over the whole of Western India is so valuable that there would never be any question of converting it into hay. The crop grown in the rains is in a different case. It is ready for cutting in September, and at that time green fodder (except in Sind) is abundant. If the weather is suitable hay may be made though the crop is somewhat difficult to cure owing to the thickness of the stems and the succulence of the leaves. The cut crop must not, hence, be heaped together

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\* See Reports, Larkhana and Landhi Agricultural Stations, 1913-14.

† Report, Kirkee Dairy Farm, 1904-05.

too soon, as it is then likely to become mouldy, and when nearly dry it must not be knocked about too much or the leaves are likely to be knocked off. We have no experience of the value of the crop for silage, but elsewhere it has been found excellent, the product being stated to be better than maize silage, and the value obtained was better than when the crop was made into hay.\*

*Yield.*—I have already indicated (page 118) the quantity of crop which has been obtained in our experiments at different seasons of the year. It may be taken that 12,000 to 16,000 pounds of green fodder per acre is a good crop when grown under irrigation. If grown in the rains the yield will be less, and not usually more than 10,000 pounds per acre will be obtained. This corresponds fairly well with the yields obtained from cowpea in America where it is so extensively grown as a fodder crop.

*Chavli as a mixed Crop.*—*Chavli* forms an excellent mixture with either fodder *jowar* or *bajri* grown for fodder, and owing to its more or less twining habit it becomes thoroughly mixed with the *jowar* or *bajri* and considerably increases the feeding value of the crop. The usual plan here followed has been to grow three rows of *jowar* and one row of *chavli*, the seed being drilled. Both grow together, and the mixture is cut when the *jowar* is ready. From experiments with various pulses (*chavli*, *val*, *mug*, *kulthi*, &c.) in 1897, *chavli* was found to be the best for mixing with fodder *jowar* on medium or heavy soils. It gave the biggest yield of any of them. On light soils it should be replaced by *kulthi*. When so grown in mixture, the ruling factor in determining the time of cutting is the crop with which it is grown, that is to say, the *bajri* or the *jowar*. Hence it is usually cut very young long before it would be reaped if it were a single crop, and hence the weight given is only relatively small.

*Enemies of Chavli.*—Two somewhat serious pests attack *chavli*. The first of this is the aphid (*Aphis rumicis*) which often injures the crop grown under irrigation in the hot weather. The crop is only occasionally damaged seriously with us. The attack can be detected at once by the bending over of the growing tips of the plants, the curling up of the leaves, and a general air of unhealthiness over the plants. Nothing can be done, except to cut the crop and feed green at once, and trust to getting a return from a second growth. Any spraying method for a crop like *chavli* would be out of place.

The second serious pest not only of *chavli* but also of *val* and several other pulse crops, is a hairy caterpillar (*Amsarta lactinea*).† The moths of this caterpillar appear at the beginning of the monsoon and lay many eggs on the broad leaves of these leguminous plants. Each lot of eggs contains two hundred or more small, round, pearly coloured eggs. The caterpillars which come out feed together on the epidermis of the leaves. Plants which have had eggs laid on them can be marked down even from a distance. At this stage, the peculiar habit of the caterpillars feeding together is so characteristic that they only move to a second leaf when the food on the first is fully

\* Doane—Maryland Agricultural Experiment Station, Bulletin No. 98 (1905).

† I am indebted for the substance of the account of this pest to Mr. R. S. Kasargode of the Poona Agricultural College.

consumed. After the caterpillars have moulted three times, they alter their habits and separate singly in search of food. They then grow rapidly gradually increasing in length up to two inches. They are very hairy: the hairs on the abdomen are yellow, those on the thorax are black. The pupa is formed in the soil, and remains there until the following monsoon when the moths again hatch out. The moth is easily attracted to light, and is a beautiful insect with white wings and a crimson border along the front edge of the forewing.

This caterpillar pest is common in Gujarat on most of the leguminous plants grown in the monsoon, but is very much less destructive in other parts of Western India. The chief means of control lies in recognising the plants that have had eggs laid on them; and if these plants are picked out before the stage at which the insects begin to wander, large numbers of the insects can be destroyed before they have done serious injury. Attracting the moths to light has been advised in the case of a closely related species in Madras and Mysore.

No fungus disease has done serious damage in Western India, though the fact that the well known root fungus, *Rhizoctonia solani* has been found to attack the plant at Pusa\* renders the possibility of such an attack here not very remote. If such an attack does occur, the crops had better be cut down, the land ploughed at once, and the crop avoided for two years at least on the land.

*Chavli* as a Fodder.—*Chavli* is one of the most valuable leguminous fodder crops we have for all kinds of stock. It is rich in proteids in particular, and analyses of the very similar cowpea hay (when completely dried) grown in America are as follow†:—

	Cut in full bloom.	Cut when pods forming.	Cut when pods formed.
	per cent.	per cent.	per cent.
Ether extract (fat, &c.)	4.04	3.06	5.01
Proteids	17.86	19.93	21.38
Digestible Carbohydrates, &c.	52.28	50.58	32.59
Fibre	18.29	18.52	29.05
Ash	7.43	7.91	11.97

This shows that the proteids increase in this case after the pods are formed, as the seeds are very rich in this constituent. When ready for feeding off the following co-efficients of digestibility of the various

\* Butler—Report, Agricultural Research Institute, 1911-12.

† See Piper—Forage Plants, page 502.

constituents of the fodder have been given by American authorities\* with cattle:—

Dry matter	68	per cent. digestible.
Fat	59	" "
Proteids	76	" "
Digestible carbohydrates	81	" "
Fibre	60	" "

There is practically no waste in feeding *chavli* fodder. Even when it is a little mouldy it is eaten freely by stock of every kind, and this is of course a great advantage. Altogether it would seem that *chavli* is likely to fill a large place in the fodder supply of Western India as a crop of exceeding high feeding value, easy to grow, and which stands ahead of all other known annual leguminous fodders for growing in the hot weather under irrigation, or in the rainy season. In addition to these advantages the long tap root of the plant penetrates the sub-soil loosening it and making it more porous, and the residue left in the soil after cultivation is always sufficient to produce considerable improvement in the land. It is a good soil improver as well as a good fodder crop.

### XIII. VAL.

An annual fodder crop which seems, in its own place, likely to be of equal value with that last discussed is *va* (*Dolichos lablab*) known outside India as the hyacinth bean. This is a native of India, and it is cultivated on a very considerable scale in the Bombay Presidency either for the sake of the green pods as a vegetable or for the seed. In most other parts of India it is known as a garden crop; or else it is grown in a mixture with other crops. Here only it is a regular field crop and becomes in the Thana and Kolaba districts by far the most important pulse cultivated. But in spite of this, it is not at all grown as a fodder crop purely, though of course the plants after removal of the seeds are fed to cattle. Its development for fodder purposes primarily will be almost a new thing.

In the search for suitable fodder crops it early commanded attention, and from the beginning showed great promise. It was found to grow luxuriantly in good land in the rains and also in the *rabi* season in Poona. In this part of the country, however, it quickly showed itself inferior to *chavli* as an irrigated crop in the hot weather, and somewhat inferior to it even in the rains, but was considerably superior as a crop for the late rains or the *rabi* season. As a rains crop its relation to *chavli* is well shown by the following yields obtained in 1894 and 1895:—

	Yield of green fodder 1894 per acre.	Yield of green fodder 1895 per acre.
	lbs.	lbs.
<i>Chavli</i>	12,089	7,346
<i>Val</i>	7,998	7,528

\* See Voorhees—FORAGE CROPS, page 366.



In the hot weather *val* often almost failed: in 1895, 5,143 pounds of green fodder per acre were obtained at this season.

These results have been confirmed nearly all over Western India, but *val* has achieved a most striking success in Sind, where it is probably the most promising of the *kharif* pulses.

The yields at Mirpurkhas have been as follows:—

Year.	Yield per acre of green fodder.	Remarks.
	lbs.	
1910	12,000	First cutting only. Gave a good second cutting.
1911	22,000	In three cuttings.
1912	16,533	Do.

Thus we have a crop which is almost ideal as a *kharif* fodder for Sind, as it gives repeated cuttings of good fodder before ploughing into the land for the *rabi* season. The conclusion reached as a result is that "*val* as a pulse fodder is unequalled: *chavli* is next."

The present position generally is that in Western India *val* can be relied upon to give a crop of 7,000 or 8,000 pounds of green fodder in the rains, or in the *rabi* season with irrigation. For the latter purpose it will do better than any other. In the special conditions of Sind, it is probably the best annual leguminous fodder crop for the *kharif* season.

*Val* is a more twining and climbing plant than *chavli* or indeed than any of the common pulses. In its early growth its tissues are very tender and soft, and hence it is delicate, and liable to slight attack by quite a number of insects. In most of the varieties the flowers are white, but one vigorous variety grown in the Konkan has purple flowers. No experiments have been made as to the relative value of different varieties from a fodder point of view.

On the whole *val* seems to prefer a medium or stiff soil,—a stiffer soil than is the best for *chavli*. Grown in the *rabi* season, for which it is most suitable in the greater part of the Bombay Presidency, it does not need irrigation if the water level is not far from the surface, but if a large yield of fodder is wanted, irrigation will, in nearly all cases, be of advantage in the later part of the growth, except in particularly damp places. While requiring much moisture, *val*, however, will not flourish in waterlogged places. Grown for grain, it will stand considerable drought,—even more than *chavli*, but under drought conditions the amount of fodder yielded is relatively small.

The method of cultivation is similar to that already described for *chavli*. But the land need not be so carefully prepared as for *chavli*. One special difficulty arises in this case. Most of the pulses have a certain percentage of hard seed which will not germinate without special treatment, and in this

matter, *val*, in our experience, is the worst of all of them. If the seed is rubbed roughly and thoroughly with wet sand before sowing, all difficulty on this score disappears.

In growing it for seed in the Konkan, the land after removal of the rice crop is ploughed and cross ploughed. The plough is again worked a third time, and the seed is then dropped into the furrows made by the plough. Better than this is the use of the drill when growing the crop for fodder. About thirty to forty pounds of seed per acre are required.

The crop is cut when the beans are formed, and this is about two and a half to three months after sowing. It must be cut at an earlier stage than *chavli*, as after the crop begins to ripen the leaves get very brittle and fall off at the lightest touch. Hence it should be generally fed green and is not suitable for making into hay. Grown as a *rabi* crop, by the time it is ready, green fodder has begun to be scarce over most of Western India and it is particularly valuable. In Sind, green fodder is always valuable. I have no experience of any attempt being made to convert *val* into silage, but there is no reason to anticipate any special difficulty.

• *Yield*.—The amount of green fodder obtainable per acre can be judged from the figures already given of the yields actually produced at Poona and Mirpurkhas. Its power of giving more than one cutting is of considerable value, and enables it to produce a larger yield than otherwise would be the case. In Sind this faculty is now well recognised, and three cuttings of the pulse grown in the *kharif* season seem regularly to be obtained. No great attempt has been made to get a second cutting when it is grown in the *rabi* season, but if this could be done it would very considerably increase the value of the crop. At present one cutting in the *rabi* season over most of Western India should give from 7,000 to 10,000 pounds of green fodder per acre. In Sind, in the *kharif* season, three cuttings should give from 15,000 to 20,000 pounds of green fodder per acre.

*Val as a mixed Crop*.—*Val* can be grown as a subordinate crop with fodder *jowar* or fodder maize just like *chavli* and with equal success. It has the advantage, according to Mollison,\* owing to its very twining character, of giving a more completely mixed fodder when the combined crop is cut. Again it should be noted that with these mixed fodder crops, the combined crops are reaped when the *jowar*, maize or *bajri* (whichever it may be) is ready, without waiting for the maturity of the leguminous crop.

*Enemies of Val*.—The chief insect enemy of *val* grown for fodder, in Western India, is the hairy caterpillar, *Anasca lactinea*, the habits of which and the remedies for which have been already described under *chavli*. Other pests are of little importance.

*Val as a Fodder*.—From all experiments so far, *val* is found to be at least equal as a fodder to *chavli*, if anything being superior to it. The fodder is on the whole finer, and less inclined to be coarse: the leaves are, however, more likely to fall in the course of reaping, and hence (as already

\* Poona Experiment Farm Report, 1896-97.

noted) it ought to be reaped at an earlier stage than *chavli*, and so the highly nitrogenous seeds cannot have the same chance of developing.

The fodder can be fed without any waste, and has proved suitable for all kinds of stock.

#### XIV. KULTHI.

The best leguminous crop for fodder purposes on light land in the rainy season is *kulthi* (*Dolichos biflo us*) which, though at present only grown to a small extent for this purpose is nevertheless very largely cultivated as a mixed crop with grain crops, for the sake of its seed, almost all over the Bombay Presidency, and even more largely in Madras.

As grown in the Bombay Presidency it is a very much branching plant,—the branches intertwining very much with one another. The foliage is very pale green in colour, and is very tender when young. The ordinary variety has grey variegated seed.

As a fodder crop attention has been attracted to *kulthi* for a long time especially on account of its drought resisting capacity, and hence its suitability for growing on sandy and shallow lands during the rainy season. Even if there is a long break in the rains it does not affect *kulthi*. In Madras long ago Robertson recommended it as a catch crop for fodder to be either grazed or fed green, as the seed could be put in at any time and needs only one shower to start it growing.

In Bombay, as already stated, it is chiefly a rains crop on light land. In 1892 Mollison stated that 7,912 pounds of green fodder had been so obtained per acre at a cost of Rs. 12, while the crop was worth Rs 26, the fodder being valued at 300 pounds per rupee.\* It was soon, however, found to be inferior to both *val* and *chavli* on heavier soils, while superior to them for light land†, and under these circumstances it gave good returns both alone and as a mixed with fodder *bajri* or *jowar*. It was recognised as a better fodder even than *val* or *chavli*.‡

In Sind its cultivation was taken up as a *khari*f fodder at Mirpurkhas in 1910; § but it did not succeed, the growth being poor and the fodder, of little use. So much was it a disappointment that it has not, apparently, been tried again since.

From these experiments it would appear that we have in *kulthi* a first class crop for light land in the rainy season, probably the best we have. It seems to be no use in Sind. Under all conditions of growth where successful it has only given one cutting.

*Kulthi* will grow really successfully only on light land, and this kind of soil is the only one on which it should be put. Mollison remarks in this connection " *kulthi* is essentially a light soil crop, and is extensively grown on the light red stony soils of the Deccan. It does well also on poor sandy

\* Bombay Agricultural Department, Bulletin No. 15 (1892).

† Poona Experiment Farm Report, 1895-96.

‡ Report, Poona Experiment Farm, 1897-98.

§ Report, Mirpurkhas Agricultural Station, 1910-11.

soils. It only requires a moderate rainfall, and succeeds better than any other pulse in light soil which is in poor condition.\* The preparation of the soil and the manner of cultivation does not differ from that already described for *chavli*. When grown for fodder it should be sown more thickly than when grown for the seed, and twentyfive pounds of seed per acre be required. The principal crop will be in the rains, but repeated crops can be taken off the same land without difficulty if the necessary irrigation can be arranged. Mukerji† recommends taking three crops in succession for fodder, sown in June, August and November, and reaped, respectively, in August or September, October and January. Robertson suggests that it may follow a *rabi* crop, and so furnish green fodder in the hot weather at the least expenditure of water; the reaping of the crop commencing a month only after sowing.‡

Most of the *kulthi* grown in Western India is now grown in admixture with *bajri*, one row in four being *kulthi*. The system gives a very good mixed fodder.

When grown alone the yield which may be expected has been already indicated. Mukerji (*loc. cit.*) says that five tons of green fodder can be obtained per acre. This, however, would be a high yield on most of the soils on which *kulthi* is grown with us. As already noted the fodder is very good in quality. If the plants are cut when in flower, it is excellent for all farm-animals (Mollison), and especially in mixtures is considered as particularly good for milk animals. Mukerji notes that a mixture of *kulthi*, unripe *bael* fruits, and *kanta-notia* (*Amaranthus spinosus*) is used by *goalas* in Bengal to stimulate the flow of milk in their animals.

The analysis of fresh *kulthi* fodder grown at Poona gave figures as follows:—

Moisture	71.5 per cent.
Ether extract (fat, &c.)	0.6 "
Proteids	3.4 "
Digestible carbohydrates	12.9 "
Woody fibre	7.5 "
Ash	4.1 "
	100.00

## XV. GUAR OR CLUSTER BEAN.

A good deal of attention for fodder purposes has recently been given to *guar* (*Cyamopsis psoralioides*) which though a minor crop in the West of India (except in Northern Gujarat) possesses considerable advantages in certain cases. As usually grown it is a garden crop, except as regards the so-called *deshi* variety, which is grown as a dry crop subordinate to *bajri*.

The special advantages which *guar* is supposed to have are (1) that it is very drought resistant and hence will give a good crop with very little water in irrigated tracts; (2) that it is particularly suitable for light

\* Text Book of Agriculture, Vol. III, page 83.

† Hanb ok of Indian Agriculture (3rd edition), page 203.

‡ Saidapet Farm Reports.

sandy soils ; (3) that the plant is an upright growing plant, which hence has a number of advantages over the twining, creeping, climbing pulses already dealt with ; and (4) the fodder produced is relished by animals.\* Its disadvantages are that it grows comparatively slowly, and will not grow well on black cotton soil.

*Guar* is a stiff erect plant, with single stems or a few branches only which grows up to six feet high. "The leaves are trifoliolate and angularly toothed. The small flowers are numerous in short, erect axillary racemes. The pods are flat,  $1\frac{1}{2}$  to 2 inches long, and about seven seeded."\*

Experiments in Western India as a fodder crop have chiefly been made in Sind, where it shows considerable promise, for growth in the *kharif* season. At Mirpurkhas, planted in June, and cut for the first time in August, it has been reported on as follows :—

1910-11—Excellent fodder, relished by cattle. The second cutting was poor, but the first cutting gave 13,000 pounds of green fodder per acre. The local variety grew well, but another with large pods, obtained from Karachi was preferred.

1911-12.—12,000 pounds of green fodder was obtained per acre. There was no second cutting. The same remarks as to variety hold as in the preceding year.

1912-13.—The local variety gave 16,000 pounds of green fodder per acre, while the Karachi only produced 10,200 pounds. There was no second cutting of fodder.†

At Landhi, near Karachi, it has given a very heavy yield of fodder.‡

In the remainder of the Bombay Presidency few experiments have been made with *guar* as a fodder crop. At Dharwar once it was established it was found to resist drought well,—but did not appear to be suited to black cotton soil.

*Soil and Cultivation.*—In fact, in *guar* we have a crop essentially suited to sandy or alluvial soils, and under these conditions it can be grown with success by practically the same methods already described in the case of *chavli*, though it can be planted perhaps a little closer than in the case of the latter crop, say, in rows from twelve to eighteen inches apart. Ten pounds of seed per acre are required. It is particularly suitable for growing in the rainy season, being sown at the beginning of the rains and cut when in flower or when the pods are beginning to form. It will usually be ready at the end of August if planted early in June. If seed is wanted, it will have to be left till October.

*Yield.*—The account given above of the Mirpurkhas experiments indicates the yield of fodder which may be expected under suitable conditions. In Bengal, Mukerji states it should give from 8,000 to 16,000 pounds of green fodder per acre,§ and that with *chavli* it occupies the first place among annual rank growing fodder crops.

\* Piper—Forage Plants, page 557.

† Reports, Mirpurkhas Agricultural Station, 1910-11, 1911-12 1912-13.

‡ Report, Landhi Agriculture Station, 1913-14.

§ Mukerji—Handbook of Agriculture (3rd edition), page 205.

*Guar as a Fodder.*—All our local experiments agree that green *guar* is an excellent fodder and is relished by all our agricultural animals. When young it is very free from fibre.\* Hitherto it has always been fed green here when grown as a fodder crop, and there seems no experience as to its value for hay making or for silage. The analysis in my laboratory of two lots of young fresh *guar* plants grown at Loni near Poona gave the following figures:—

	(1)	(2)
Moisture	77.0	73.8
Ether extract (fat, &c.)	0.7	0.8
Proteids	4.6	4.3
Digestible carbohydrates	10.5	8.9
Fibre	4.0	7.9
Ash	3.2	4.3
	100.0	100.0

## XVI. SOY BEANS.

Soybeans (*Glycine soja*) as a fodder crop have been much utilised and recommended during the last few years in many parts of the world, and have, in a number of centres, made a place for themselves as a field crop for this purpose. As grown for seed, it may be stated that soybeans form a large crop in Northern China, Manchuria, and Japan, while the plant is also cultivated to a very considerable extent in the hills of North-East India.

The crop is an annual, and is erect and branching with (as grown in India) somewhat slender stems, though imported varieties are usually very much stouter. The stems are hairy and the leaves vary from a long and narrow lanceolate shape to broad and almost circular. So far as Indian experience goes, the crop as usually grown demands a moist temperate to sub-tropical climate such as is found in the Naga hills. In America the crop matures practically under the same range as maize, except that the soy bean will not flourish under conditions as tropical as those under which maize will grow. Hence in introducing the crop it must be remembered that it is not adapted to a very hot climate, but is rather suited to a lower temperature and less tropical conditions.

This may account for its practical failure when grown in the rainy season in Western India. It was first tried at Poona † in 1905-06 and grown in the rains, when it seemed to be unhealthy throughout its growth and only gave 331 pounds of green fodder per acre. It has been grown in small plots every year since that time, but the results have always been similar.

In 1911-12 and succeeding years, a number of American varieties and also a Java type have been tried in various centres. At Dhulia in 1911-12 in the rains, the Java soybeans grew well, gave a large quantity of leaf, and came to maturity in three months, giving 400 pounds of grain and 2,240 pounds of stalk per acre. The American varieties (Haberlandt, Hollybrook

\* Duthie and Fuller—Field and Garden Crops.

† Poona Experiment Farm Report, 1905-06.

and Medium Green) grew much shorter not higher than nine to twelve inches high, and only yielded from 280 to 415 pounds of grain and from 120 to 400 pounds of stalk per acre. In the following year at Dhulia the results were even less satisfactory. The Java beans gave no grain, and but, 2,180 pounds per acre in the plants as a whole; the American varieties gave a similar amount of grain to the previous year and straw from 573 to 1,083 pounds per acre. At Dharwar the same varieties as at Dhulia did very poorly in 1911-12. Java soybeans did very badly, and none were promising, and they were even less successful in the following year. Thus at two centres on black soil the results were a practical failure when the crop was grown in the monsoon.

On alluvial soil the results at the same season were no better. At Nadiad on the light *goradu* soils of Northern Gujarat, the crop was a complete failure in the monsoon in two successive years. At Gokak, on sandy soil in the Deccan, Java soybeans went to leaf, but even then only gave a very small yield.

So that in all our centres the crop has not been a success in the rains. On the other hand few experiments have been made with soybeans as an autumn (*rabi*) or cold weather fodder, though this is the season to which it would seem naturally adapted. In 1915, however, it has been grown on a small scale on the Kirkee Military Dairy Farm as an autumn crop, and the results, unlike those quoted above seem to show considerable promise. It was suggested as a crop to put into the land after the monsoon to improve the soil and give leguminous fodder for the cattle at that season, and has created a very favourable impression.\*

As to manner of cultivation, soybeans close resemble *chavli*. They have a strong central root, and broad leaves but instead of being of a twining habit, they have stiff stems, and are upright plants. The best soil for them is said to be a stiffish loam or clay. It should be prepared as for *chavli* and the seeding should be similar to what is recommended for that crop. The rows may perhaps be a little wider apart, and twenty-four inches is not an unusual distance between the rows in America. The quantity of seed will vary from thirty to forty-five pounds per acre according to the distance apart. The seed should not be planted too deep, as this is said to be a frequent cause of failure. A depth of one to one and a half inches seems suitable. The seed should germinate within a week.

The crop will require irrigation if a large crop of fodder is to be obtained, and if it is put in September and October, the only period of the year when it has any promise in Western India.

The crop† may be cut for feeding at any time from the setting of the seed until the leaves begin to turn yellow. This takes 2½ to 3 months up to the setting of the seed. It is probably most suitable when the pods are well formed. At a later stage, the stems become woody, while the content of proteid diminishes, and many of the leaves drop off. The yields obtained in America vary between three and six thousand pounds of hay per acre, corresponding to about seven to fourteen thousand pounds of green fodder. Whether as large yields as this are likely to be obtained here is a matter for further experiment. A second crop cannot ever be obtained.

Soybeans are said to grow very well with maize, and are very commonly grown in America in admixture with it in alternate rows. The crop is then often converted into silage, though this would be hardly likely to be done here.

\* Private communication from Mr. G. H. Frost to the author.

† Most of these details are obtained from Piper, *Forage Crops*, pages 515 to 530.

As a fodder, the crop is richer in proteids than most other leguminous crops, but it is more woody and fibrous than *chavli*, and hence less palatable to stock, while there is more waste in feeding. The average composition is given by Voorhees\* as follows, with the percentage of digestibility:—

	Composition.		Percentage of digestibility.	
	p. c.		p. c.	
Moisture	...	75.1		
Ether extract (fat, &c.)	...	1.0		55
Proteids	...	4.0		78
Digestible carbohydrates	...	10.6		77
Fibre	...	6.7		45
Ash	...	2.6		
		100.0		

It must be recognised that soybeans are as yet in a very early experimental stage here. They are, however, proved to be definitely a failure as a rains crop, but show considerable promise as an irrigated *rabi* crop. It is for this latter purpose they are here suggested.

## XVII. PEAS.

The ordinary field pea of India (*Pisum sativum*) is, when grown separately, of little use as a fodder crop. It only gives a comparatively small yield when grown in the cold weather, and if grown in the rainy season the plants will mildew and only give an insignificant return.† At the same time it is generally recognised throughout Western and Northern India that the plant furnishes very valuable fodder,‡ and is one which grows very well indeed in mixture with other crops, and particularly with oats. As a result while one may say that peas alone are never grown for fodder purposes, oats and peas grown together have become one of the standard sources of fodder round cantonments, in dairies, and other similar places where such crops have been grown. I shall exclusively deal with this and one or two similar combinations under the present heading.

Peas and oats are essentially a *rabi* crop to be grown under the conditions and by the methods already described for oats. The peas grown with the other crop increase its yield and feeding value without in any way reducing the vigour with which the oats grow. The land best suited to growing this combination is well manured, deep, moist soil, and the crop grows best in the height of the cold weather. It must not be planted too early, say not before the end of September, and may be sown much later, say up to the end of November in most of our areas, though experiments on this matter in the colder conditions of Sind are wanting. At Poona good results were obtained with seed planted from October to January.§ The land should

\* Voorhees—Forage Plants, pages 266 and 366.

† Poona Experiment Farm Report, 1893.

‡ See Watt—Commercial Products of India, under *Pisum*.

§ Poona Agricultural College Station Report, 1912-13.



be well manured with cattle and other farmyard manure, and this should be broadcasted after ploughing at the rate of twenty to twenty five cartloads per acre (say eight to ten tons).

The crop can well be sown with a drill in the same way as described for oats, reserving one row or more in every four for peas. Often the seed is simply sown mixed. In America it has been a common custom to sow the peas a few days before the oats, but, on the whole, experience seems to be against this method and they may just as well be sown together. There is no difficulty, in well prepared land, in sowing the mixed seed broadcast, and then burying the seed by a light harrowing. The land in most of our areas will almost always need irrigation before sowing, unless the crop is put in very early in the season. The amount of seed required will be from sixty to eighty pounds of oats and twenty pounds or more of peas per acre according to the proportion the peas are intended to form in the resulting fodder.

Irrigation will be required at intervals of about ten days after the crop has begun to grow in average black soil, but the amount will vary with the character of the land. The crop is as a rule ready for cutting about 2½ months after seeding and should be harvested when the oats are in the milk stage and the peas are forming pods. If needed for feeding green it need not all be cut at once, and a crop from a single seeding may last in very good condition for at least eight or ten days. If this is to be done, the cutting should begin a little before the stage already recommended. If continuous green feed is needed, this can be obtained by seeding several plots at intervals of a few days from October to December.

The yield of the mixed crop is very variable. When young the fodder is very watery, but at the stage recommended it is as rich in feeding material as most other green crops, and, thus cut, the yield of green fodder with a well grown crop varies from ten to twenty thousand pounds per acre. I may give some examples of yields actually obtained here. At the Poona College Dairy Farm, where it is a regular crop, seed sown in October gave crops of 15,208 and 11,200 pounds of green fodder per acre in January in different parts of the farm in 1911, and this represents about the average yield there. At Manjri in the same year 10,038 pounds per acre were reaped, the cost being Rs. 51 per acre and the value of the produce Rs. 84. The yields elsewhere are not widely dissimilar.

It has been customary to feed the crop green, but it makes excellent hay, and at the time of the year when it is ready, it can be made into hay without any difficulty. If this is done, it should not be cut later than the stage already stated.

I have not got any analyses of local grown fodder, but the following are American figures for a crop grown from seed consisting of two bushels of peas to one and a half bushels of oats, and hence containing more peas than recommended above:—

	per cent.
Water	... 79.4
Fat (Ether extract)	... 0.7
Proteids	... 2.1
Digestible carbohydrates &c.	... 10.0
Fibre	... 6.2
Ash	... 1.6
	<hr/> 100.0

The fodder is said "to exert a very favourable influence on the physical quality of milk."\* It is hence a crop worthy of much consideration for the *rabi* season by all those who are growing crops for dairy cattle.

Peas are sometimes grown as a mixed crop with *khapli* wheat in a similar manner to that just described with oats. This does not seem to have very many advantages over the crop with oats, except perhaps that it can profitably be sown a little earlier in the season.† But the methods to be followed and the yield likely to be obtained do not differ appreciably from those already indicated for peas and oats.

### XVIII. METHI OR FENUGREEK.

The fact that the growth of *methi* or fenugreek (*Trigonella foenum-graecum*) as a purely fodder crop has existed and still continues in certain parts of Western India, and more particularly in the districts of Nasik and West Khandesh is a very interesting one, and would seem to show that in this part of India the crop has special and peculiar advantages which make it worthy of consideration by those engaged in fodder growing. Of course, the crop is far more generally grown either for its seed (which is a well-known condiment cultivated considerably in North India) or as a green vegetable, when it forms a much appreciated *sag* if pulled up after the two seed leaves are formed. Our purpose is, however, with it purely as a source of fodder.

At present its cultivation for the purpose of producing fodder is carried out, not only in India, but also in the countries bordering on the Mediterranean, and especially in Egypt. In the last named country it is cultivated both alone and as a mixture with vetches and berseem, when it gives a cutting after two months' growth. With vetches, about one quarter the amount of seed used when it is planted alone is sown, and it then acts as a standard on which the twining vetch plants can climb. In Egypt it is planted about the end of October when the Nile flood is passing off.‡

The methods of cultivation now in vogue with us in the Nasik district are of a special character.§ It is either produced under well or canal irrigation and the system employed differs considerably in the two cases. If grown under well irrigation it grows taller than in the other case, and pays better. In either case *methi* fodder is the main-stay of the work bullocks during the hot weather in many parts of the Nasik district, and most of the people cultivating under well irrigation devote about one-fifth of the area to the growth of this crop. The proportion is usually about one acre for seven bullocks, and it is the chief food in the day time for a month or so during the hot weather.

The soil used for the purpose is a well-drained medium black soil with *murum* underlying it. If a thin layer of the so called *shadu* lies between the black soil and the *murum* the best conditions are supposed to be reached. Abundance of lime in the soil appears to be necessary. If grown on lighter and poorer soils more irrigation water is needed, and less succulent fodder is obtained. Undrained soil leads to attack by aphids, and checks the tillering

\* Voorhees-Forage Crops, page 187.

† Poona College Agricultural Station Report 1912-13.

‡ Foaden and Fletcher—Text-Book of Egyptian Agriculture, page 561 (1910).

§ I am indebted for most of what follows to an article by Athalye, Poona Agricultural College Magazine, Vol. VII (1916), page 226.

so necessary to produce the best yield. It may be noted that recent investigation indicates that the root nodule bacteria found on the *methi* plant are of the same species as those found on lucerne, and so it is likely to grow on similar soils, and on soils which have carried lucerne\*.

Under well irrigation the crop follows *bajri* and the latter crop is given all the tillage necessary to leave the soil in good condition for *methi*. From fifteen to twentyfive cartloads (six to nine tons) of farmyard manure per acre are also given to the previous crop. *Methi* itself is planted without ploughing, the land being raked or harrowed by hand, and receiving no special manure. It is usually followed by sugarcane or onions.

The seed should be plump and yellow in colour† and is sown from October to February, the coldest weather being supposed to give the best results. It is sown broadcast by hand in beds thirty six to forty feet long and six feet broad, after the removal of the previous crop, the sowing rate being thirty two to thirty six pounds per acre. It germinates in four or five days. The seed is covered and mixed by a light harrowing, and watered immediately. A second watering follows after a fortnight, and a third after a further three weeks. After this time the crop is watered every two weeks, the total number of irrigations needed being six if the crop is used for fodder. If left for seed one or more further waterings are required.

The crop is reaped when nearly three months old, the plants being uprooted. The reaping continues for three to four weeks according to the requirements of the farm animals or the market. It is always fed green, and on an ordinary cultivator's holding is pulled up for the bullocks each day for the midday feed.

The yield of *methi* fodder obtained is stated to be about eight to ten thousand pounds of green fodder per acre, and an acre will feed eight bullocks (one meal a day) for three to four weeks. A standing crop is worth Rs. 60 to Rs. 75 per acre and costs about Rs. 36-12-0 to grow of which Rs. 23-8-0 represents the cost of irrigation. In experiments in California one variety of fennugreek has produced 15,518 pounds of green fodder per acre‡, but I doubt whether this yield is often reached here. It shows however what the crop is capable of producing.

The only serious disease attacking the crop is aphid, and this particularly affects the late sown crop and usually appears in March or April. The crop sown in October and November seems to escape the attack.

By far the greater part of the crop is grown under well irrigation as described. But where canal water is available it is also produced though the methods differ slightly. Under these circumstances it is usually taken after rice or after groundnuts. The land is ploughed twice, the seed broadcast, and the field then levelled, beds formed, and the crop immediately watered. No special manure is used, but the rice crop which precedes it is usually green manured with *tag* (*Crotolaria juncea*). Groundnut however receives no manure. The seed rate employed is twenty pounds per acre, but the yield is twenty five per cent. less than is obtained under the more careful conditions of well irrigation.

On the whole it would seem that *methi* is well worth attention as a cold weather irrigated fodder crop capable of being grown well on into the hot weather. It is not expensive to grow, the chief charges being for irrigation,

\* See Klemmer and Kruger—Centralblatt für Bakt. (II), Vol. XL (1914), page 256.

† Reddish or yellowish green seed is considered inferior. The usual price of *methi* seed is 8 to 12 pence per rupee.

‡ Stau bei Rauch—California Agricultural Experiment Station Report, 1904.

and it yields a fairly heavy crop of good succulent fodder. So far no experiments have been made here, or elsewhere, as to the relative value of the fodder, but its continued and extending use among the cultivators of the Nasik district suggests that it possesses considerable merits.

### XIX. OTHER LEGUMINOUS FODDER CROPS.

None of the many other leguminous crops have been very often tried as purely fodder crops in Western India, though the vines of most of them when grown for seed are used for feeding to animals. It is hence not possible to say much with regard to them, and none of them are of such promise as to demand recognition and recommendation. I will merely note in each case what has been done in the way of experiment, with some estimate of the possibilities in each case.

*Udid* (*Phaseolus mungo* var. *radiatus*) and *mug* (*Phaseolus mungo*) are two pulses both very extensively cultivated for their seed. They give under these conditions stalks which make excellent fodder, but as purely fodder crops these do not seem any conditions under which they are likely to compete with *chavli*. In any case they are grown at the same time of the year and on similar soils to *chavli*.

In Poona in 1897 on medium black soil, *mug* was grown as a fodder crop in the rains, and proved itself inferior in yield and general value to both *chavli* and *val*, though it was better than all other leguminous crops than these on medium and heavy soil.\* The result was so conclusive that no further experiments have been made in the matter. In recent years experiments have been made in Sind, at Mirpurkhas, again as a *kharif* crop. The results both with *mug* and *udid* seem quite clear. The yields, though fairly good, are considerably inferior to both *val* and *chavli*, and were as follows:—

1910-11—*Udid* 13,000 pounds of green fodder per acre.

*Mug* 12,000            do.            do.

The crop in each case was obtained in August and no second cutting was obtained.

1911-12—Both crops grew vigorously, and were eaten off by stock so that no record of yield can be given.

1912-13—*Udid* 9,600 pounds of green fodder per acre.

These figures† give an idea of their value relative to other crops. In other places the results have been similar. In land not well drained they are liable to die off completely in the rains, and in Dohad in 1910‡, the crop was destroyed by a *Rhizoctonia* fungus.

On the whole I cannot consider that either of them affords much promise as a fodder crop in Western India. All that they can give, will be given better by *chavli*.]

*Math* or *Matki* (*Phaseolus aconitifolius*) is in a very similar position to those last dealt with. As a crop for seed it is exceedingly largely grown, standing fourth in the order of importance among leguminous crops in the Bombay Presidency, but as a fodder crop it has no special advantages.

\* Poona Experiment Farm Report, 1897-98.

† Report, Mirpurkhas Agricultural Station, 1910-11, 1911-12, 1912-13.

‡ Dohad Agricultural Station Report, 1910-11.

Definite experiments have, I think, only been carried out at Mirpurkhas (Sind) with this pulse as a fodder. It was there tried in the *kharij* season under irrigation, planted in June and reaped in August, giving yields as follows:—

1910-11—12,000	pounds per acre of green fodder.	
1911-12—11,700	do.	do.
1912-13—16,000	do.	do.

In no case did the crop give a second cutting. While giving better results than *udid* and *mug*, it is still considerably inferior to *val* and *chavli* and cannot compete with them. The fodder is perhaps rather better in quality than that of *chavli*, but not sufficiently so to make up for inferior yield.

*Sann Hemp (Crotolaria juncea)*.—In the south of the Bombay Presidency young sann hemp plants are often cut for feeding to stock, the crop being afterwards allowed to grow for fibre. And inasmuch as this crop produces a very large amount of green matter per acre, it has been frequently suggested to grow it definitely for fodder. Experiments have, however, not been favourable at Poona. The first attempt was made in 1903, when the crop was grown thickly, as for green manuring, being planted in June and allowed to grow until it flowered. The crop was then cut and amounted to 27,920 pounds of green matter per acre. It proved, however, at this stage much too fibrous for fodder, and the cattle refused to eat it.\* In the following year it was again grown and cut very young before flowers began to appear. In this condition the cattle ate it, but not with great relish, while the crop was not sufficiently large in quantity to encourage further experiments.† In fact it seemed that if allowed to grow long enough to produce a large crop, it was uneatable; if cut when young enough to eat, it gave an altogether inadequate crop and even then, was not a good fodder. This is the Poona experience, but on the other hand in somewhat similar conditions it has yielded well and is considered as of considerable value as an irrigated fodder crop in the hot weather. It is evidently well worth further trial in this direction.

*Florida Velvet Bean (Stizolobium decringianum)*.—This pulse, imported from Florida, has been used to some extent in the warm damp parts of the United States for fodder chiefly as a pasture plant, and as a mixed crop with maize and sorghums. On the whole, however, even there its cultivation has not developed very largely. In Western India, it was tried at Poona in 1905-06, the seed, at the rate of about twelve pounds per acre being dibbled on good well manured land early in July. At the end of September the total produce only amounted to 4,136 pounds‡ per acre. As it would be essentially a crop for the rains if grown at all, this result was not encouraging enough to cause the experiment to be proceeded with. There hardly, in fact, seems any reason for supposing that Florida Velvet Bean has any advantages over several of the other leguminous crops available at present.

*Florida Beggar Weed (Desmodium tortuosum)*.—This is another American introduction which seems to have some promise in the neighbourhood of Karachi where it has been recently introduced as a possibly useful *kharij* fodder. The experiments on it have only just commenced, however, but at

\* Poona Experiment Farm Report, 1903-04.

† Kirkee Dairy Farm Report, 1904-05.

‡ Kirkee Dairy Farm Report, 1905-06.

Landhi (Karachi) after one year's trial, it was considered as worth further experiment, as it grew high on sandy poor land, but the fodder, though eaten, appeared woody\*. In view of this opinion the following details with regard to the crop as grown in America may be useful. From eight to ten pounds of seed per acre are needed, and should be sown broadcast on the area in which it is to be sown. The land must be in a thoroughly moist condition before sowing and it can be only grown in the warmer parts of the year. The seed must not be covered too deeply. If it is cut when the first flowers appear, a second crop will be obtained; if not, after full bloom the lower leaves will fall and much of the value will be lost. If the plants are allowed to ripen, the pods open and the seed scatters and sows itself, ready for the next season. The highest yield on record was 4,630 pounds per acre in four cuttings, which appears very small. As a matter of fact, its only value appears to be to keep light poor sandy land under some sort of leguminous herbage, either without any irrigation or with a minimum of irrigation, for it seeds itself and will possibly give a crop on such land year after year with the minimum of attention. I cannot say that the possible utility of the crop seems to be great.

The following crops have after trials so far given no promise of being useful.

*Japan Clover*† (*Lespedeza striata*).—This has been tried in Sind (Mirpurkhas 1908), at Dharwar (1909), and at Poona (1909). At none of these places has it shown any promise. Considerable difficulty has been found in getting the seed to germinate, and the crop shows no likelihood of being useful.

*Vetches* (*Vicia sativa*)—were tried as a rains crop in Poona as long ago as 1893.† They were put in in June and germinated well, but only produced plants giving a very few flowers and no seed. The crop was considered to have no promise of being a success. A second experiment in 1912 was no more promising, and the crop was shown to be unable to stand the hot weather §.

*Sainfoin* (*Onobrychis viciifolia*) has been experimented with at Poona as long ago as 1893†. It however, proved after repeated trials, a total failure as a rains crop, and also in the cold weather. It did even worse than vetches as a rains crop, and the seedlings soon died.

*Lathyrus sylvestris* var. *Wagneri*.—A few years ago this crop was boomed as a first class perennial fodder crop, and it was tried in many parts of the world. It has, however, proved a general failure almost everywhere. In Poona, it was grown for three years but proved "a miserable failure," as elsewhere in India. In the report of the Poona Farm (1893) the following remarks were made by Mollison. "The plot on the Poona farm has survived more than a year, but in the hands of an ordinary cultivator it would have been extinct long ago, because the expenses incurred in weeding and watering have already far exceeded any prospective return which the most enthusiastic cultivator could forecast. I must give the plant credit for enormous root development, but unfortunately this growth is in the wrong direction, for nothing that could be called fodder has yet been gathered." The crop presented in a gradually dying condition for two years more, and then disappeared.

\* Landhi Agricultural Station Report, 1913-14.

† Mirpurkhas Agricultural Station Report, 1908-09; Dharwar Agricultural Station Report, 1909-10; Poona Agricultural College Station Report, 1909-10.

‡ Poona Experiment Farm Report, 1893.

§ Report, Agricultural College Station, 1912-13

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## CHAPTER I.

### Some characteristic Agricultural Features of Sind.

By T. F. Main, B.Sc., Deputy Director of Agriculture in Sind.

Sind proper consists of a huge alluvial plain through which passes the river Indus. On the West there is a different type of country consisting of rocky mountainous lands where little cultivation is possible. On the East there is the desert which consists of low undulating sand hills. The Sind plain is watered by a net-work of canals which draw water from the Indus. Agriculture in Sind is for all practical purposes, dependent upon the River because the rainfall is almost negligible except in the south where it is very uncertain. The Indus is a remarkable river. At certain seasons it carries an immense volume of water—the measured discharge at Sukkur having approached the colossal figure of a million cusecs. At other seasons of the year the volume of water contracts to very small dimensions, falling below 20,000 cusecs. Corresponding with these enormous seasonal variations the surface of the water rises and falls through a range of some 17 to 20 feet. This fluctuation in the level of the river determines the amount of water passing out into the canals. In practice the level of water in the river is sufficient to feed the canals for some 3 to 4 months. Owing, however, to a special arrangement at Rohri, water is drawn out of the river for the whole year to feed the system of canals in East Sind, of which the Jamrao is the best known. This supply, however, is not assured, and these canals suffer more or less deficiency each year. The Sukkur Barrage Project is designed to guarantee a regular supply of irrigation to a tract of some 6 million acres but this will not materialize in full for another dozen years.

In these circumstances a good season in Sind is determined by the behavior of the River. If it rises steadily in the second quarter of the year—maintains a good level in the third quarter and subsides not earlier than the fourth quarter, then a prosperous year may be assumed. Unfortunately this standard rarely materializes in practice; and nearly every year is characterised by one or other of the following defects; a late rise—an intermediate drop or a premature fall.

As regards the canal system the striking features are the irregular direction and numerous bends. In the North and Centre of Sind huge spoil banks mark the whereabouts of the canals. These are the consequence of "clearance work" which is a characteristic piece of cold weather work. The water entering the canals is heavily laden with silt and this becomes deposited—so much so that if clearance is not regularly done many canals would cease to draw water. On the right bank this is less noticeable in Larkana District owing to the lower level of the country—much of which receives "flow" water, whereas on the left bank it is usual for the water to be lifted on to the land by hurlas and nars (Persian wheels). This brings us to another very characteristic feature of Sind—the water wheel which is driven by bullock gear. The work goes on night and day, and the noise of the unlubricated wooden machinery is

a very familiar sound. The bullocks or camels work in shifts—a shift being about 6 hours. The cultivator and his family erect temporary sheds and take up their positions adjacent to their wheels for the season.

Perhaps the feature of the country which attracts most attention from a visitor, is the vast expanse of uncropped land. From the window of a railway carriage, you may look for miles up to the horizon, without noticing more than just a very slight amount of land under crop. The reason for this is that the water supply from canals bears no proportion to the available land. Hence we have what are known as “Sind fallows”, *i.e.*, in Sind a piece of land will only be cropped once in two, three or more years. These long fallows have one very interesting consequence—there appears to be a very vigorous restoration of fertility to such fallowed land, so much so that the succeeding crop assumes a remarkably vivid green colour which is not noticeable in other parts of the country. The explanation is not fully understood but the conditions prevailing in these fallow soils must favour nitrification in a peculiar and intensive manner.

The next feature in the country-side which obtrudes upon one's notice, is the presence of kalar salts in the soil rendering them more or less unfertile through all stages up to the point when nothing can grow. This kalar is distributed sometimes over hundreds of acres—but very commonly it occurs in patches giving the fields a mottled appearance like the colouring of marble. Fortunately this kalar is not universal but it is never far away. It would in fact be difficult to pick out a block of 5 acres of land anywhere in Sind and to say there is not a single kalar patch in this area. The amount of salt present varies very much. Here the crop may only be slightly stunted, while there it may have failed to germinate. It has been proved by careful investigation that the injurious effect of kalar is largely physical by spoiling the texture of the soil, rather than directly poisonous to the plant. The kalar salts, however, frequently become so concentrated in the soil solution as to cause direct injury to the plants.

As a result of kalar salts and also owing to certain other factors such as sand in the soil—it is rare ever to see a uniform stand of crop over even a small field in Sind. This does not prevent good average yields being obtained, but this is due to some parts of the crop being very good.

The sand trouble just referred to, is the result of the alluvial origin of the soil. Everywhere in Sind sand is met with if you dig deep enough. Where the sand appears near to the surface, cultivation is most difficult as nearly all crops greatly deteriorate as soon as their roots enter the sand.

In Sind there are practically no metal roads and transport is mostly on pack animals of which the camel is the characteristic exponent of this mode of transport.

In the vicinity of towns, the roads are somewhat better looked-after but even within a short distance of Hyderabad you may meet with

conditions rendering a horse conveyance a dangerous means of travelling. Bridges are also a formidable consideration to the traveller. Even when he resorts to riding, his mount may temporarily lose a leg through a hole in the surface of the bridge, superficially covered. In the north of Sind a good deal of produce is transported by a simple type of country cart—and also in parts of Hyderabad a much better cart is in use—but a long string of pack camels—as depicted in the photo represents the predominant mode of moving produce.

Hot scorching winds prevail in the hot weather months. These are very strong in the south of Sind where they cause volumes of dust to pour through the atmosphere. The worst time for such winds is the 40-day period known as the Chaliho commencing about the end of April.

In the north of Sind these winds do not prevail, but on the contrary the atmosphere is intensely still and close—but whenever a breeze does spring up, the air feels like a hot blast from a furnace.

Owing to these hot winds and also because of the intense heat of the sun, shelter is a matter of the greatest importance. This applies particularly to garden areas and public roads. No garden should be established without first providing a strong wind-break or shelter on one or more sides of the area selected. The photo shows a wind-break of casurina trees, but for general utility nothing surpasses the tali tree (Shishum), of which there is a very fine wind-break at Mirpurkhas Experimental Farm. This tree makes a most excellent shelter. It grows rapidly and is in full foliage during the hottest part of the year. These shelters are also required for service in the cold weather, particularly in the north of Sind where intensely cold winds blow anytime in December and January—but these are more or less spasmodic.

The importance of road-side trees cannot be overstated. With them the traveller can get along in reasonable comfort. Without them he suffers severely for the very ground heats up to such an extent in some places as to be difficult to walk over without protection for the feet. Sufficient discretion in selecting road-side trees, is not always exercised. For example the Sirus tree is frequently chosen for this purpose—but it loses its leaf in the early part of the hot weather and it is distinctly a brittle tree. Probably the two best road-side trees are the Neem and the Tali. The babul is also a useful tree for this purpose—but it is liable to much destruction on account of its other valuable characters, such as fodder and lac.

The Huri is a well known mark on the Sind landscape. This is a piece of land which is set aside for irrigation but not for cropping. Strictly speaking, it is grazing ground, but tree growth is so rapid that it assumes the appearance of a plantation or forest rather than grass land. This is not objectionable because the tree growth, not only provides grateful shade to stock during the hot hours of the day, but also makes a large contribution to the food supply. Land assigned to this purpose is left for about 10 or more years. Then it is brought back into cultivation when most excellent crops are produced.





1 A View of the Fuleli Canal showing a Camel working a Persian Wheel in the left hand corner.



2. A View of the River Indus



3. A View of a Modern Canal.



4. A View of a Distributing Channel.



3. A View of a Modern Canal.



4. A View of a Distributing Channel.



5. A Casurina wind-break.



6. A Huri, or sheltered grazing ground.

## CHAPTER II.

**The lines along which improvements in Sind Agriculture are possible.**

By T. F. Main, B.Sc., Deputy Director of Agriculture in Sind.

Perhaps the simplest and most easily adopted improvement is that of seed. There are two sides to this problem. First there is the variety and secondly there is the quality of the seed itself. Where the variety is inferior for any reason then the solution lies in substitution and replacement by a superior variety. But apart from this, the quality of the seed may be bad from several causes. For instance wheat seed may have been the produce of a crop which was badly rusted or the seed may have been stored carelessly so that much injury has been sustained from weevil attack.

Cotton seed on the other hand may have been damaged by boll-worm or in the process of ginning—or rain may have fallen on it and caused it to heat.

Whether the seed supply is unsatisfactory from either of these stand-points, the change arising out of the use of good seed of a good variety, offered by the Agricultural Department, involves practically no extra trouble to the cultivator, while the extra expense is almost negligible. It is as easy to sow good seed as bad, while the Department does not want to make a profit out of the sale of seed, but wishes merely to cover expenses. Of course when a certain class of seed has acquired a high reputation and has passed into the trade then a substantial premium is charged, but the extra amount forms a very small percentage of the total expenditure on producing such crops as cotton.

Hence it may confidently be asserted that good seed is the most popular improvement that can be offered by the Agricultural Department.

It is not always realized how great is the contribution of good seed to the ultimate profits of an acre of produce. Take for example the seed of 27 W.N. cotton (an improved form of deshi) on the one hand, and ordinary deshi on the other. The former variety has a high ginning percentage. The ginning percentage of deshi cotton grown on the Jamrao area is 13.75 seers of lint per maund of seed-cotton—while the ginning percentage obtained from 27 W.N. at Mirpurkhas has been 16 seers of lint. Hence because of this higher ginning factor alone, the man who adopts 27 W.N. cotton, will produce 116 bales of cotton where previously he produced 100 bales only—which means a net addition to his profits of Rs. 10 per acre at least.

Similarly a good variety of wheat may reasonably be expected to yield 10 per cent. more than the ordinary bazar seed of an ordinary variety. Hence on a 20 maund crop per acre there would be an additional two maunds worth Rs. 9 or 10 per acre.

In these circumstances, it is in the interests of all cultivators to make a point of securing good pure seed of a superior variety. Government are prepared to incur considerable expenditure upon the improvement of

crops. Improved varieties cannot be produced haphazard. It is necessary to provide institutions like Experimental Stations, and to appoint crop breeders to conduct the work on sound scientific lines. At present we have only one crop breeder in Sind, viz., the Cotton Breeder but that officer with the assistance of his subordinates is also engaged in the breeding of improved varieties of rice and wheat. The shortest time required to breed an improved variety is three to four years. Such work is very valuable, especially when the great staple crops are the subject of the operations because of the vast areas affected. Thus an improved rice which increases the profit per acre by only Rs. 10, when grown on an area of three lakhs of acres—means an addition of 30 lakhs per annum to the net profits of Agriculture in the locality concerned.

Cultivators should insist upon getting the best quality of seed. It can generally be arranged with factory owners to gin the second and third pickings of cotton separately and to set the seed apart for sowing purposes.

A second direction in which great improvement is possible, lies in cattle breeding. Broadly speaking the draft cattle of Sind are much below the standard of quality desired. In many parts they are undersized and badly shaped, so that they cannot adequately perform the cultural operations requisite in the production of good crops. Similarly the yield of milk by the average cow is very much less than it need be, and enormous improvement is possible. Here again the effort required of the people, is not great. All they have to do is to employ superior bulls and to see that these bulls and not inferior village bulls cover their cows. By using good bulls the quality of the cattle can be greatly improved in a couple of generations. The real labour involved in this improvement, rests with Government who have to establish breeding herds and employ highly skilled officers to direct and control the work. This involves a great amount of expenditure and hence the public should co-operate in every way in taking full advantage of the facilities provided, by castrating, or at least segregating, the inferior bulls and by taking great care of those issued by Government. In Sind the Willingdon Cattle Farm has been established where work on two breeds will be conducted. For detailed information reference is invited to the article by Mr. Bruen entitled Cattle Breeding in Sind.

Thirdly, there is the adoption of superior implements. For these to be successful, they must be reasonably cheap and light of draft and efficient. It stands to reason that there can be little improvement in the standard of agriculture so long as the whole cultivation of the land depends upon an inferior wooden plough. In this way the land is never properly tilled, while it is impossible to get rid of troublesome weeds except by repeated operations which take up much valuable time. Without efficient clod crushers a good seed bed is impossible, unless hand labour is resorted to, which is actually the case in such places as Hyderabad taluka, where a man breaking clods with a mallet is a familiar sight. Without a suitable drill, the seed has to be broadcasted which is almost universal in Sind, outside the bosi wheat tract. There is an immense field for improvement by adopting superior implements, but unlike seed this improvement

generally means some extra outlay in money and some extra labour in making use of the implements. Hence this improvement belongs to a different category from that of seed, namely the category which definitely demands an additional effort from the cultivator.

For this reason the adoption of this improvement is slower than that of seed.

Closely associated with improved implements, are improved methods. In Sind it is customary to broadcast the seed of the principal crops such as cotton instead of sowing it in lines. Herein we have a large field for improvement. The advantages of line sowing are obvious. By it inter-cultivation can be carried on by cattle, whereas at present the expensive operation of hand hoeing is indispensable. The Department of Agriculture has been demonstrating this method through the agency of trained coolies working under the Propaganda Officers, for some years and a number of progressive zemindars are adopting it, at least in part. It is peculiarly suitable for light free working soils and where areas are extensive. On the stiffer kalar-impregnated soils it is less applicable but the Department is engaged in designing a drill which will do good work in such soils. Another obvious improvement in method is the transplantation of rice. In the Eastern Nara area rice is still broadcasted. This improvement involves some effort as the labourers have to be trained and made accustomed to the routine, and it involves additional expenditure which however is well invested, as is evidenced by the universal adoption of this method in all well managed rice tracts.

Another opening for improvement is the intelligent cultivation of Fruit. This is almost a neglected branch of agriculture in Sind. Nevertheless the Province possesses a number of special advantages for this class of farming. The soil is a deep alluvium. There is very little rain. Pests and diseases are very limited. For these reasons the grape vine thrives better in Sind than in almost any other part of India—and the yield of produce is heavy. Oranges and lemons (or limes) also do very well. The North of Sind along the riverain tract is particularly suited to dates. A reference to the article on "Fruit-growing in Sind" should be made by all interested in this line of agricultural development.

Finally there is enormous scope for the control and reduction of crop and animal diseases including insect and vermin pests. Among cattle there is annually great havoc caused by rinderpest. This is aggravated by the delay which is common, in giving information to the Veterinary Department. Yet the results obtained from inoculation are so striking that the losses from this cause could be enormously reduced if the people were more active in co-operating with the Veterinary Officers. With regard to crops it is only necessary to refer to the heavy damage sustained from rust in wheat. Some varieties of wheat are immune to rust—hence the importance of growing immune varieties. Nearly every year the mango crop is badly damaged by Mahlo disease which can be controlled by spraying. In the field, rats cause enormous damage to crops like rice and wheat—but the use of poison baits has proved very effective, at least in the case of wheat.

## CHAPTER III.

**The Staple Crops of Sind and their improvement.**

By T. F. Main, B.Sc., Deputy Director of Agriculture, and K. I. Thadani, M.Sc., Cotton Breeder.

Sind is a cereal growing Province.

The areas under the principal cereals in 1920-21 are noted in the

Name of crop.	Area in acres.	margin—but there is a good deal of fluctuation from season to season, depending upon the facilities for irrigation. Thus a late rise in the Indus River which feeds the canals, may reduce the Bajri area.
Rice ..	.. 1,235,173	
Bajri ..	.. 937,001	
Wheat ..	.. 345,990	
Jowar ..	.. 408,385	

A high river in August-September, means a large wheat area. In recent years, wheat reached 675,361 acres in 1917-18, and Jowar reached 604,980 acres in 1919-20.

After cereals cotton is the most important crop. This is not due so much to the area, which, under existing conditions, is only some three lakhs of acres—as to the large profits which are made out of this crop.

Both cereals and cotton grow remarkably well in Sind—but it is rare to see a uniform crop all over a survey number. There are always inferior patches which are generally caused by either the presence of "Kalar" salts or sand in the soil. Average outturns, however, rule high.

The Agricultural Department has devoted chief attention to cotton and wheat and more recently to rice.

## COTTON.

The cotton cultivated in Sind is a mixture of Neglectum types—similar to the cotton which prevails over a great part of Central India. There is however an opening for American cotton in Sind, and hence operations have been along two main lines.

- (1) The improvement of deshi.
- (2) The production of a suitable variety of American.

For the time being there is more scope for improving deshi than introducing an American variety—as the latter is restricted to the area commanded by the Jamrao Canal.

Sind deshi cotton stands in a class by itself among Indian cottons. For trade purposes it falls within the broad class known as Bengals, but it possesses certain distinctive features of its own, which distinguish it from other Bengals. It has the two characters of brightness and roughness developed to a high degree, which secure for it a strong demand both in Europe and Japan.

Thus notwithstanding the fact that it possesses no staple—it commands an excellent price. The characters mentioned above, render this cotton specially suitable for mixing with wool, and in the year 1922-23 the up-country rate for this cotton ranged from Rs. 12 to Rs. 17 per maund of 84 lbs. of seed cotton. It possesses the further excellent characters of



being early and very prolific. The ginning percentage varies from locality to locality but in the factory of Messrs. Ralli Brothers at Mirpurkhas it gives a ginning percentage of  $33\frac{1}{2}$  per cent. ; and it is chiefly in connection with ginning percentage that the Agricultural Department has been able to effect an improvement. Careful work has resulted in the isolation of several good strains. The best strain isolated is registered as 27 W. N. This cotton is the progeny of a single plant selected several years ago.

The ginning percentage of the produce of this strain on the Seed Farm at Mirpurkhas in 1922-23 was 39 per cent. This indicates that where Jamrao deshi cotton produces 100 bales, then 27 W. N. will yield up to 116 bales from equal quantities of seed-cotton.

Messrs. Ralli Brothers who purchased the ginned cotton, grown on the Mirpurkhas Seed Farm in 1922-23, paid Rs. 44-8 per maund for it against Rs. 39-8-0, the prevailing rate for Sind deshi. This premium was partly due to the removal of stained cotton before ginning—but Messrs. Ralli Brothers reported as follows :—

“ This cotton is an exceptionally desirable type of deshi cotton owing to its great roughness and its very high class and we are of opinion that even if it were cultivated extensively in Sind it would always find ready buyers at a substantial premium over the ordinary deshi quality.”

<table border="0"> <tr> <td style="padding-right: 10px;">Variety.</td> <td style="padding-right: 10px;">Yield of seed cotton in lbs. per acre.</td> <td></td> </tr> <tr> <td>27 W. N</td> <td>1,190</td> <td>..</td> </tr> <tr> <td>Sind-deshi</td> <td>1,167</td> <td>..</td> </tr> </table>	Variety.	Yield of seed cotton in lbs. per acre.		27 W. N	1,190	..	Sind-deshi	1,167	..	<p>Experiments conducted at Mirpurkhas have not hitherto proved this cotton to yield more seed-cotton per acre than deshi. Deshi is, in fact, capable of giving an almost unlimited yield per acre if the conditions are made sufficiently favourable—thus in certain favoured places in Hyderabad, a yield of 30 maunds (2 bales) per acre has been reported. At Mirpurkhas in 1922-23 deshi and 27 W. N. were grown in 16 subplots aggregating 4 acres. There were thus eight subplots or two acres of each variety, and the average results were as noted in the margin. In 1922-23 this 27 W.N. strain gave an average yield of just on 12 maunds (954 lbs.) of seed-cotton per acre over an area of 33 acres on the Mirpurkhas Seed Farm—which approximates to a bale per acre :—</p>
Variety.	Yield of seed cotton in lbs. per acre.									
27 W. N	1,190	..								
Sind-deshi	1,167	..								

Much work has been done on American cotton. The chief problem has been to find or produce a variety which can be grown under the rather severe conditions prevailing on the Jamrao canal area. Such cotton, to be successful, must be hardy and capable of doing well under rather careless cultivation. It must also fit in with the irrigation facilities and be relatively resistant to red-leaf blight. A Punjab variety known as F4 has done very well in Sind. It matures early and releases autumn irrigation for wheat. It is hardy and prolific and is relatively resistant to red-leaf blight. This variety, however, has a short staple. Botanical work is in progress with the object of crossing this cotton with several long-stapled Americans with a view to evolving a variety

possessing all the strong points of F4 and in addition possessing an improved staple of one inch or above.

In the meantime the people are showing much appreciation for F4 in the Southern Jamrao area, and there was a keen demand for seed in March 1923. It is essential to sow this cotton early, if possible in March, but not later than May—although fair crops have been recorded from June sowings.

This cotton has proved an excellent yielder when given a fair chance.

In a comparative trial on the Seed Farm at Mirpurkhas in 1921-22 this variety and strain 27 W.N. (improved deshi) were each sown on one and a half acres with the results noted in the margin. In the same season the average yield of F4 on an area of

30 acres on the Mirpurkhas Seed Farm was just over 13 maunds (1,040 lbs.) per acre of seed-cotton. In point of yield per acre, it is clear that this cotton holds its own well with local deshi cotton.

In ginning percentage it is not so good; this amounts to 32 to 33 per cent. Notwithstanding the lower ginning percentage, Messrs. Ralli Brothers have been purchasing this seed-cotton at a premium of 2 annas on the rupee over deshi. In 1922-23 the ginned produce of F4 grown on the Seed Farm, was sold for Rs. 57-8-0 per maund against the rate of Rs. 39-8-0 for deshi on the same day.

#### WHEAT.

In Sind there are some 17 varieties of wheat. These have been carefully classified and described, and improved strains of the more important varieties have been isolated. At the same time some of the best wheats grown in other parts of India have been tested, and a few of these have given excellent results in Sind. We are now able to recommend different varieties and improved strains for different parts of the Province. Thus in the North of Sind nothing has done better than Pusa 12. This wheat is a good yielder and the grain is of high quality.

The flour is greatly appreciated in the Indian home, and it has been highly reported upon in the English market. In the field, this is a very attractive wheat with large ear-heads. It is moreover resistant to yellow rust, unlike all the local varieties. For these reasons it has met with high approval in the North of Sind, and the Department is endeavouring to get it grown on a large scale, in the first place in the Sukkur taluka. On the Government Wheat Farm at Jacobabad in 1921-22 an area of 44 acres sown with (Cawnpore) Pusa 12, gave an average outturn of 18·3 maunds (1,464 lbs.) per acre. This was a "bosi" crop, i.e., not watered during the period of growth. The irrigated crop has frequently exceeded 20 maunds per acre. In point of yield, however, this wheat has strong rivals in certain strains of Phundani and Thoree, local varieties. Thus C Ph 49, a strain of Phundani, has yielded up to 26 maunds per acre on a small scale on the Sukkur Farm. This variety however is susceptible to rust in the field and weevil in the store where the grain gets badly damaged. Mr. Thadhani has, however, recently isolated a new strain of

Phundani having pink straw—which appears to be comparatively immune to weevil attack, and less susceptible to rust. It has been noted that Pusa 12 variety has a tendency to lodge on irrigated land but this is probably due to the tendency to irrigate too soon after sowing and before the root system has penetrated deep. It is highly desirable that this variety should be well and deeply rooted before the first irrigation is given.

In East Sind on the Jamrao canal area, it is necessary to grow an awned or bearded variety, owing to bird trouble. In this tract Punjab 11 has met with great favour. This is a good yielder and a hardy variety. It exceeds 20 maunds per acre under favourable conditions—thus at Mirpurkhas Experimental Farm in 1922-23 an acre yielded 1,714 lbs. of grain.

A good strain (G S 36) of Sindhi white wheat is expected to do well in the Nara Valley; while in the south of Hyderabad District where Sindhi red wheats prevail, it will be possible to provide an F. S. strain, to replace the present mixture of three varieties. This strain is a heavy yielder, comparatively less susceptible to rust and early, and the grain is relatively weevil resistant. It also possesses stronger straw than the mixed wheat at present cultivated in the tract.

In the South of Sind it is found difficult to store wheat owing to the damp climate which favours weevil attack—hence the economic importance of producing weevil resistant varieties is very great, strong straw is another character of much economic importance; this also is receiving special attention. Steps are taken to maintain the purity of these improved strains by protecting a certain number of earheads each season, as shown in the photo, to prevent cross-fertilization. This seed is sown in the following season on a small plot called the breeding patch—which in turn supplies seed to the increase block—which in turn supplies seed to the Seed Farm where it is further multiplied before issue to the public.

#### RICE.

Work of a similar character has more recently been commenced on rice at Larkana Experimental Farm. The three marginally noted varieties have been chosen for improvement. The objects aimed at, are to produce more prolific varieties and to intensify earliness.

Jajai Sugdasi.  
Prong Sugdasi.  
Kangani.

Special attention is being paid to sterility (or Khas). It is found that a certain number of flowers do not produce fertile grain. This phenomenon varies from season to season and between varieties. In some seasons sterility may rise to 32 per cent. of the possible grain.

Other staple crops will be taken in hand as staff and funds become available. Of these Jowar will be the first. Some preliminary work has already been done in classification and in studying Agricultural characters. There are some 60 varieties of Jowar in Sind but only a few are of real importance.



**7. American Cotton on Mirpurkhas Seed Farm**



**8. Jowar crop at Sukkur.**



9. Pusa 12 Wheat at Mirpurkhas

## CHAPTER IV.

**Some Agricultural Machinery and Implements in Sind.**

By T. F. Main, B.Sc., Deputy Director of Agriculture, Sind, and Mahomed Umarchan Barakzai, Dp.Ag., Superintendent, Wheat Farm, Jacobabad, and Umershan Dinmahomedshah, Superintendent, Government Farm, Mirpurkhas.

The most important tillage implement is the plough. The deshi plough is of the usual type found in India in various forms. The first improvement effected by the Department of Agriculture was the introduction of the Egyptian plough which is fully described in Sind leaflet No. 1. The important features about it are (1) it has a broad share, (2) the angle between the body supporting the share and the pole can be varied by an adjustment, (3) the share is made of steel and is spear-shaped and is fixed to the body by a bolt and nut. This plough has many practical advantages over the narrow sharp pointed deshi plough which does not stir up the whole soil but leaves untouched portions between successive furrows. Owing to the broad share the Egyptian plough moves the whole soil and cuts through the roots of grass and weeds. It moreover covers one and a half time as much area as the deshi plough and moves the soil to a greater depth of some two inches. The Egyptian plough is primarily intended to be used in conjunction with irrigation—the ploughing to commence when the land has sufficiently dried. This plough is not intended for “dry ploughing” except where the land is naturally light. This plough has been widely taken up in certain parts of Sind especially in the neighbourhood of Mirpurkhas. The annual output of these ploughs by three mistries in the Mirpurkhas bazar amounts to some 1,200.

The steel share is sold by the Department for a price of Rs. 2-8 and is a great improvement on the locally made shares made out of “kharo loh” and “mitho loh” which cost respectively Rs. 1-12-0 and Rs. 2-4-0.

The next step in ploughs is a light iron plough, and some of these are described in Sind leaflet No. 13. Among these the Rajah is a particularly good plough and limited numbers have been sold to the public but the current price Rs. 55 is more than the public are prepared to pay. This plough is double handled and in Sind it is generally necessary to employ two persons, a man and a boy. In these circumstances there appears to be a greater immediate future for a one-handled iron plough with a pole so that the ploughman can handle the plough with one hand, and being placed close to his cattle, can drive them easily with the other as in the case of the deshi and Egyptian ploughs. Such a plough has been found in the “Orient” manufactured by Messrs. Ransomes Sims and Jeffries—but the current price of this plough is Rs. 42, and hence it is essential to reduce this before any general introduction is possible. Mr. Schutte, Agricultural Engineer to the Government of Bombay, is now working upon a design of a similar plough which he anticipates can be made in India and sold for a price of about Rs. 15. This plough will embody the general excellence in the design of the Orient plough such as lines of curvature on the mould-board and share, with certain improvements

which will give greater strength to the body and facilitate a wider range of adjustment for dealing with different classes of soil, or with soil in different conditions of moisture.

In the meantime the Meston plough of which a local imitation is made—is finding increasing favour, especially in Jamesabad taluka and the Department is actively engaged in popularizing it.

After the plough there is no implement more valuable or effective than the roller or clod crusher. When in action it meets with the unreserved approval of the zamindars and haries. This is not a very cheap implement nor is it required every day by the same man. It is essentially an implement to be shared by several persons and should be owned, either by a zamindar or Co-operative Association. Messrs. Howard of Bedford have designed a special size of roller for Sind having a width of only 4 feet, as it was found that the English models of 6 feet were too heavy for cattle. The former can be hauled by one pair of strong cattle—its “rings” are 17 inches in diameter and are “notched.” This machine costs Rs. 300. Mr. Schutte is also working upon a modification of this roller with a view to reducing the amount of material put into the frame, and generally he hopes to reduce the cost and increase the efficiency by preventing damp soil adhering to the “rings.” He hopes to turn out a good roller for a price of Rs. 150 approximately.

The special uses of this implement are to break down the clods which are formed when cultivating the stiff soils of Sind and to act as a “packer” in bringing the moisture up into the seed bed. The effect of this pulverizing and packing is very marked, in causing the moisture in Jamrao soils to rise into the top layer of soil, immediately below the dry mulch. This machine has also been used with marked effect on young wheat in the North of Sind—bringing up the moisture as reflected in the colour of the crop.

The Marwari cotton drill is an example of adaptation. The Marwari deshi plough is the foundation on which a simple one-coultered drill for cotton sowing is made. It costs Rs. 10-8-0. There is nothing special to note about this drill as it is on the usual lines of deshi one-coultered drills found in India. The Marwar plough was found more suitable than the Egyptian plough for the purpose as it opens a narrower furrow and penetrates a little deeper—thus ensuing the seed reaching the moist soil without exposing too much furrow surface to the drying effects of sun and wind. The use of this drill is described in Sind leaflet No. 27. It has been found more suitable than the two-coultered drills used in Gujarat and elsewhere because it is capable of working in a seed bed more roughly prepared, and hence sowing operations can be pushed on rapidly as is always advisable in the kharif season owing to the rapid loss of moisture from the soil. In fact it is advisable in soils containing any kalar to sow on the same day as the first tillage operation is performed after the irrigation water has dried up. It is due to the promptness of sowing that the broadcast method gives a fairly good germination and hence drilling or line sowing to be successful must provide for this condition.

With these considerations in view efforts have been made to find a drill which would sow cotton seed more efficiently than this one. Hence it appeared probable that a drill with disc openers would prove efficient as they have great penetrating power, especially when used on land where the clods are still moist. Accordingly an American drill manufactured by Messrs. John Deere and Company of Moline, Illinois, has been imported. This is known as No. 236 cotton drill. This drill has been under trial at Mirpurkhas in the 1923 sowing season and it appears to have certain very strong advantages. It is perhaps rather too complicated for direct introduction among the public—but it seems to provide the essential principles of design which should be incorporated into a simpler make of drill, suitable to put into the hands of the public.

For wheat drilling the three-coultured drill in use in Khandesh has been found useful in the "bosi" area of North Sind. This is described in Sind leaflet No. 28—but among more expensive implements the Hoosier Wheat drill costing Rs. 470 in Bombay has done excellent work on Jacobabad Wheat Farm. It sows with unfailing regularity and to the desired depth. An area of six acres per day can be sown. It requires one pair of strong bullocks but as the draught is considerable, it is found advisable to use a different pair in the morning and afternoon. There should be an opening for it in the north of Sind among large zamindars or hiring depots.

Water-lifting from canals is perhaps the most onerous agricultural operation of the year in some parts of Sind, such as Hyderabad and Nawabshah Districts. Here a high percentage of the total cultivated area is entirely dependent upon water lifted from the canals by bullock or camel power. The machine in universal use for this purpose is the Persian wheel in two forms—(1) The Hurla and (2) The Nar. In both cases the principle is the same and the design consists of a wheel supporting an endless rope bearing small earthen vessels which pick up the water and empty it into a trough. In both cases the power is conveyed through simple gearing worked by cattle or camels walking in a circle. In the case of the Nar this gearing is located on one side of the water-wheel while in the case of the Hurla the gearing is located above the water-wheel. The former is for the deeper lifts while the latter is used on lifts within about three feet. A complete Nar costs about Rs. 133 and a Hurla about Rs. 81-0-0.

The problem of improving on these simple devices is complicated involving both technical and economic factors.

Among simple machines the Agricultural Department has brought two water-lifts to the notice of the public. These are :—

- The Bullock screw, and
- The Dutch Wheel.

Full particulars of these machines are given in Sind leaflet No. 4. Both are intended for use on quite low lifts and hence are alternatives to the Hurla and not to the Nar. In both there is a certain amount of gearing involving iron spur wheels. The Bullock screw costs about Rs. 400 and the Dutch wheel about Rs. 1,165. For these two reasons (1) the relative



high price and (2) the iron work requiring some attention from a mistri; at least to set-up, these machines have not made any strong appeal to the public. The advantages such as the greatly enhanced output of water do not sufficiently balance these disadvantages in public estimation and this must also be ascribed partly to an economic factor, namely the zamindar-tenant system of cultivation. The average tenant is a man without capital who cannot afford to purchase these machines; whereas he is able to incur the cost of a Persian wheel out of the takavi advanced by the zamindar.

The zamindar on the other hand considers it unnecessary for him to provide an improved water lift because the tenant is responsible for lifting the water.

With regard to the Nar the most promising improved water lift which will deal with a fluctuating lift is the "Aquatole". This machine however is expensive—the current price being Rs. 1,670 for a model which "lifts" one cusec of water. This machine however could be worked with bullock power by means of a gear. In the Aquatole and bullock-gear we probably have the solution of the problem of improving upon the Persian wheel (both Hurla and Nar) without giving the cultivator something beyond his capacity in skill and capital outlay—but it will be necessary to modify it with a view to a material reduction in price. Work on these lines is highly desirable.

If the employment of bullock power is not a condition of the problem of water lifting, then the obvious solution is an engine and pump. There are a great range of such pumping plants on the market and it is unnecessary to go into details of description here. The important economic fact is that this form of pumping-plant is above the head of the people—until they can be given greater assistance. In the immediate neighbourhood of Hyderabad there are ideal conditions for pumping water out of the Fuleli canal, a great number of plants (possibly 100) have been set up at one time or another, but the majority have failed owing to the ignorance or carelessness of the owners and not to unsuitable conditions. In practice the mistries engaged on these plants neglect their duties, and soon the machinery has to be scrapped or worked at a loss. If Sind had a fully qualified engineer who made the training and supervision of mistries one of his major duties it is probable that great developments in pumping from low level canals would take place. The economic difficulty referred to above between zamindar and tenant would not arise in the same way—if a large volume of water were handled by a pump under the control of the zamindar—because in that case he would make his arrangements with his tenants on a "flow" instead of on a "lift" basis.

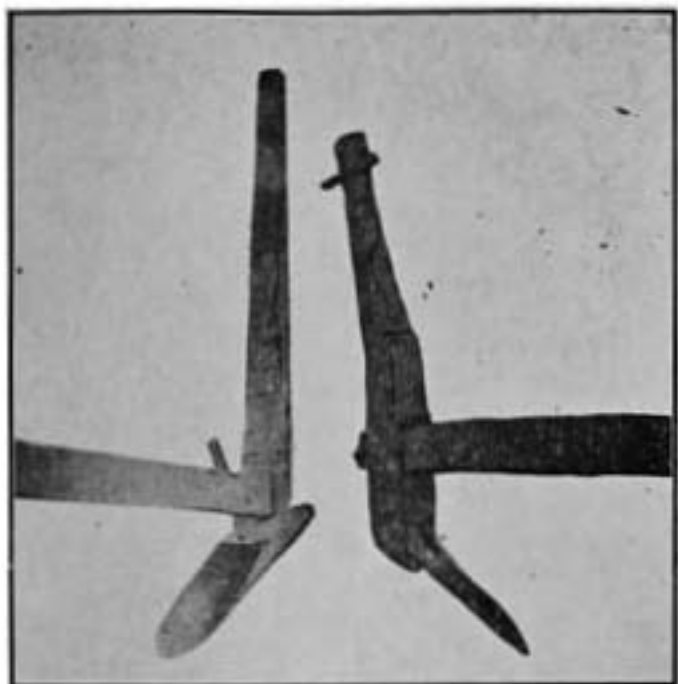
In this connection it is important to recognise that even when the Barrage system of canals comes into force there will still remain large areas of lift-land in other parts of Sind.

One of the most troublesome operations which the cultivator has to do in Sind, is the winnowing of his bhusa after threshing has been completed. This is always done in Sind by means of the wind. In many parts of Sind

however there is almost a complete absence of wind for long periods of time especially in North Sind—while in South Sind the wind is so strong as to cause great trouble to the men engaged in the work. There are two common instruments in use, (a) The “sup” and (b) The Karai. The former is simply a scoop with which the unwinnowed bhusa is lifted up by the operator to his own height from which point he gradually releases the contents. When there is insufficient wind to allow this amount of fall to be effective a shovel-like wooden instrument called a “karai” is used. This is filled with unwinnowed bhusa and then dexterously swung into the air by the operator who regulates the upward throw according to the velocity of the breeze. In this way the stuff may be thrown to a height of 10 to 15 feet, resulting in the grain falling at the feet of the operator and the chaff at some distance therefrom.

At the request of the Department Messrs. Penny and Porter of Lincoln designed a special machine to deal with this work because no winnowing machine is at all efficient, as a separator of grain from bhusa. In fact a winnowing machine is designed for a totally different purpose and invariably becomes congested when operating on bhusa. Mr. Schutte, Agricultural Engineer, is now engaged in further improving upon this machine and investigating the cost of a locally made one.

Mechanical cultivation is not dealt with in this article, but a couple of photographs are included to show that this matter is receiving some attention. It has been found that the Orwell cultivator and the Norwegian harrow do excellent work when drawn by a tractor.

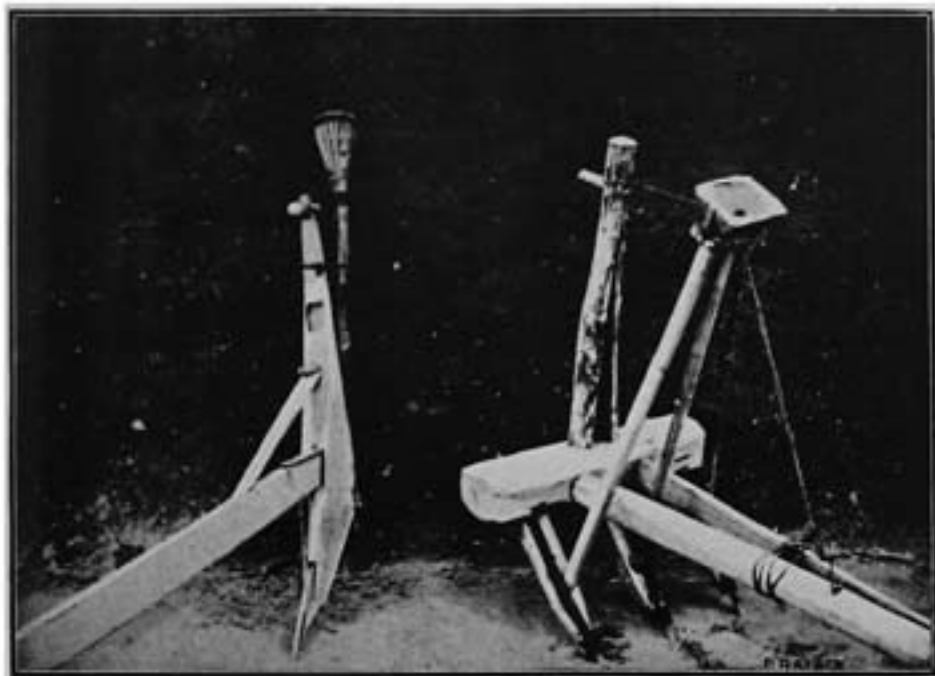


10. Left, Egyptian plough. Right, Sindhi plough.



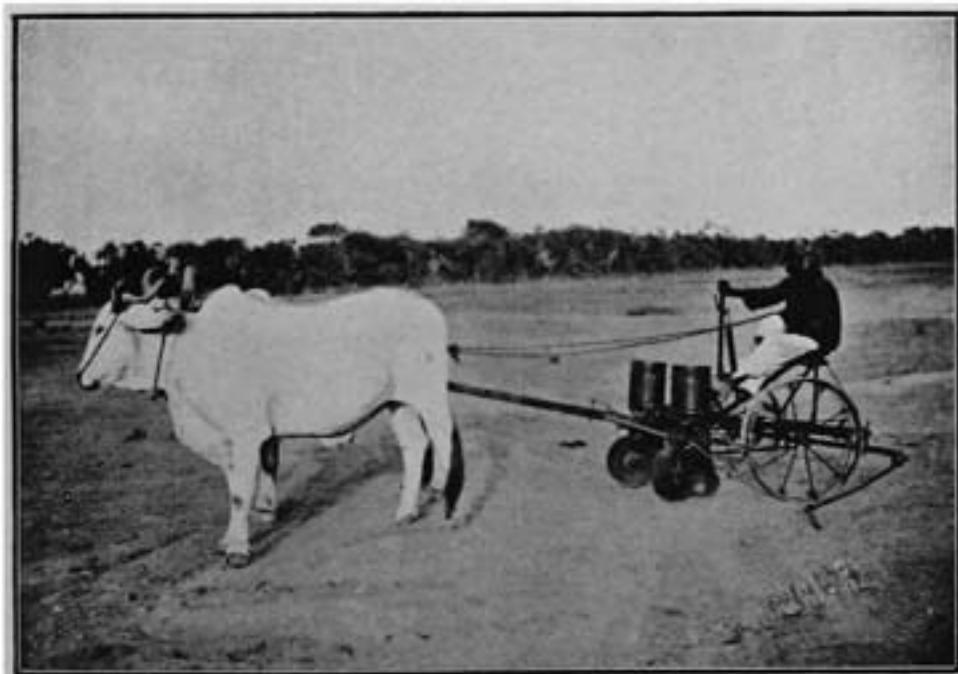
11. Left, Orient plough.

Right, Rajah plough.



12. Left, Marwari drill.

Right, Jalgaon drill.



13. Deere Cotton drill.



14. Portable Pump at Mirpurkhas.



15. Pumping, by steam engine, direct from the River at Sukkur.

## CHAPTER V.

## Cattle Breeding in Sind.

By E. J. Bruen, Esquire, Deputy Director of Agriculture for Animal Breeding.

It is more than difficult to try and conjecture how long this industry has been in existence in Sind. However one of the breeds known as the Red Sindhi or Karachi breed which is now recognised as the best milk-producing cow in India must have been bred to milk for generations past.

This small, exceptional hardy breed is bred under the most trying conditions. The parts in which it is bred are rocky or sandy soils producing no cultivated crop and a very sparse growth of grass, and this for a very short period. However it thrives and does exceptionally well. The breeder has evidently used a little judgment in his breeding operations otherwise this breed could never have produced the exceptionally fine milkers that are to be found amongst them to-day. The method of breeding has made this breed so hardy that it is able to do well under any conditions. It has been exported to Japan, Burma, Ceylon, Mauritius, Java, the Punjab and Madras Presidency, a more varied climatic change can hardly be imagined, and yet this breed has done exceptionally well.

In Sind unlike other parts of India the female progeny are given most attention, the male stock being neglected and starved with the result that the only bulls now obtainable are small and stunted. The Government have established a Breeding Farm at Pihai some 13 miles from Karachi where it is anticipated that good pedigree bulls will be bred for putting out on a Premium System in the breeding tracts and it is hoped that by this means the breed will be still more improved as a milk producer.

One photo produced is a Sindhi cow, "Iris", the property of Government on the Willingdon Cattle Farm, Pihai. She has given as much as 48 lbs. of milk a day. This is a wonderful performance when one considers the size of the breed and that the milk tests 5.5 to 6 per cent. butter fat, almost double that of the larger breeds of European cattle.

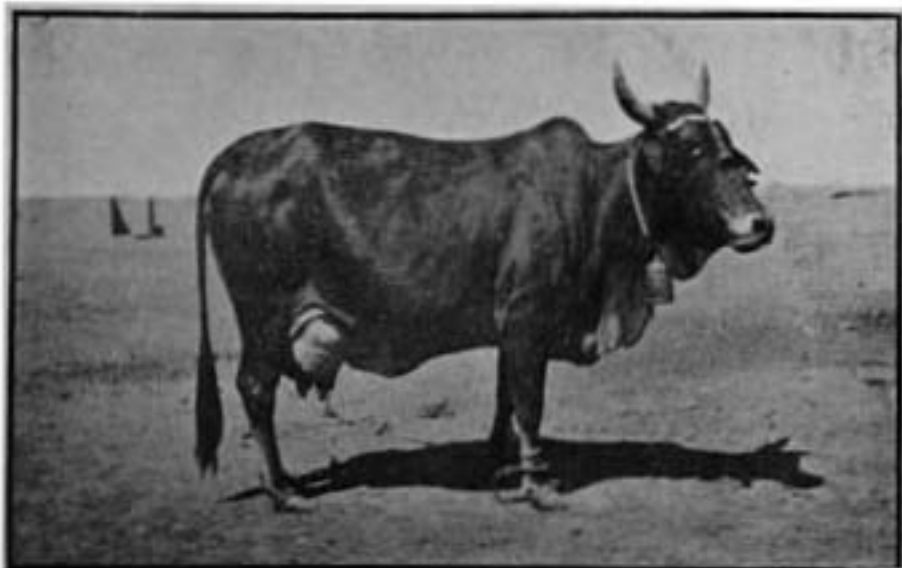
Further east, in the Hyderabad and Thar and Parkar Districts, is found another fine breed of cattle known generally as the Thar Parkar and by some as the white Sindhi. This breed has not had the prominence the Red Sindhi has as a milker, and is generally less known. However the Thar and Parkar, another extremely hardy breed, is in all probability the best all round dual purpose breed in India. It is of a handy medium size, making a very fair draught animal and is an excellent milker. It was sent in fairly large numbers to Mesopotamia during the war, and these proved to be better and more regular milkers than the Sindhi. The Government have a small herd temporarily situated at Pihai and some of the cows are producing as much as 34 lbs. of milk per diem. The breed is almost white with a grey face and black points. This breed if taken in hand, should meet an existing demand in Central India for a dual purpose breed and be the ideal for the cultivator on the new Sukkur Barrage Project, provided the draught cattle are bred to good size and weight. Government intend opening a Breeding Farm in the home of

this excellent breed to produce pedigree bulls of which the country is in great need.

The cattle in Upper Sind or North Sind are not so well bred as in the tracts already mentioned. Here the breed is non-descript and stunted. In some parts, however, are to be found the very large Baghnari breed, most probably the largest and best of our bigger draught cattle. At present however little or no breeding of the breed is carried on in British India. It is bred in the hilly rugged tracts of Baluchistan and filters through to India from the Sibi Cattle Fair.

This breed, if well cared for, should meet the needs of good draught cattle for Upper Sind. Good bulls of this breed would be most valuable for breeding first class heavy bullocks which are certain to be in demand in the Barrage Irrigation, areas where much of the soil is stiff in character, and where heavy implements such as land rollers will have to be employed. Government are now contemplating opening a Breeding Farm in Upper Sind to breed acclimatized Baghnari bulls to put out into the villages when it is hoped that big size will be bred into the existing cattle of Upper Sind.

Most of the photographs were kindly supplied by Captain Jerrom, Superintendent, Civil Veterinary Department, from the records of Dr. Haji, Deputy Superintendent, and Mr. C. S. G. Haji, G.B.V.C.



16. Cow Iris, of Willingdon Cattle Farm whose yield per day has reached 48 lbs



17. Red Karachi Bull "Roopa," Willingdon Cattle Farm.



## CHAPTER VI.

**Note on the Progress of Agricultural Propaganda Work in Sind.**

In accordance with Government Order No. 5805, dated 5th February 1923, the following eight Talukas of Sind were selected with a view to carry on intensive Agricultural Propaganda Work in them.

Khan Bahadur Azimkhan, Assistant Registrar, Co-operative Societies, Sind, with 2 Inspectors and 6 Overseers under him was appointed Agricultural Propaganda Officer.

*Names of Talukas selected for intensive Agricultural Propaganda.*

1. Sukkur.	}	North Sind.
2. Ghotki.		
3. Larkana.		
4. Kambar.		
1. Hyderabad.	}	Middle Sind.
2. Hala.		
3. Tando Allahyar.		
4. Shahdadpur.		

The main lines of work were at first chalked out, which may be briefly summarized as under :—

- (1) To popularize and distribute approved varieties of Seed.
- (2) To popularize and distribute approved varieties of Implements.
- (3) To propagate modern methods of Farming.
- (4) To organize Taluka Development Associations with a view to facilitate the above three activities.

It is needless to mention here that illiteracy, conservatism and general backwardness of the Sindhi zamindars proved to be serious handicaps towards the rapid execution of the above programme, but the results achieved under each of the four headings are very promising and satisfactory.

## 1. DISTRIBUTION OF SEED.

*(a) Wheat Seed.*

During the last Rabi season (i.e., September and October 1922) about 1,000 maunds of Pusa 12 wheat which was known in the Agricultural Department to be of very superior quality were for the first time distributed in Sukkur, Ghotki and Pano Akil Talukas of Sukkur District which is the chief wheat growing District in Upper Sind. The number of growers was about 130 scattered far and wide in the above Talukas. In Sukkur Taluka alone there were 73 growers. All land sown with Pusa 12 in the propaganda area was regularly inspected and the growers advised from time to time to observe strict care in removing the foreign plants and to guard against mixture in the threshing yards. After harvest the Pusa 12 variety has met with universal appreciation, basis for which chiefly are :—

- (1) That it has proved to be wonderfully free from rust while all other varieties suffered from it.

- (2) It has yielded much better and is more delicious than the local varieties.
- (3) Owing to its intrinsic superiority over local varieties it commands about eight annas premium in price in the market.
- (4) It ripens earlier.

The agriculturists have therefore taken a great liking to Pusa 12 wheat and so much have they grown fond of it that they are very reluctant to sell it to the Department for multiplication purposes.

*Purchase of Pusa 12 Wheat for resowing.*

Arrangement had been made this year with a Sukkur Sethia (Seth Tilockchand) to purchase Pusa 12 wheat from the zamindars and resell it at the time of next Rabi under orders of the Department. Similar arrangement had also been made at Ghotki and Jacobabad with local zamindars. The quantity thus collected is about 2,800 maunds and added to it the seed available at the Agricultural Farms and with the zamindars who have reserved a portion with themselves for multiplication purpose, the total quantity available for the current Rabi sowings could safely be estimated at 4,000 maunds.

Last year's experience has shown that it is very troublesome to distribute seed in scattered Dehs and among small land-holders. Apart from the difficulty of supervising the crops there follows a still greater difficulty of collecting the cost of seed and multiplied produce. It has therefore been deemed more advisable this year to distribute large quantities of Pusa 12 among big land-holders or at any rate in big compact areas so that distribution of seed, supervision of crops and collection of cost and multiplied seed may comparatively be an easier business.

*(b) Cotton, Seed.*

Two varieties of cotton seed were distributed for the last Kharif season, viz., 27 W.N. and the Bhit Shah seed. Of the first quality only about 300 maunds were available in the Department, of which 100 maunds were reserved for the propaganda area and 200 maunds for the Dhoro scheme. A greater portion of the seed reserved for the former went to Co-operative Societies in the Hatri Union. The area sown was cursorily watched. Germination on the whole has been fair, resowing of patches being necessary in several places. A little mixture of 1 per cent. American Cotton was found which was weeded out. The Bokhro disease was universal in all the classes of cotton and 27 W.N. did not escape the evil.

*Bhit Shah Cotton Seed.*

Bhit Shah cotton is a variety of reputed cotton in Sind. The ginneries pay a premium of Re. 1 to Rs. 2 per maund over this variety. It has a ginning percentage of about 40 and the yielding qualities higher than the ordinary Sindhi cotton. The 27 W.N. quality not being adequately available arrangements were made with one Seth Radhakirshin of Tando Adam of Shahdadpur Taluka to finance the seed. The Department undertook to inspect that the seed cotton used for ginning was

from the selected picks of Bhit Shah crops and that the ginning was regulated at proper speed to avoid breakage of seed. After ginning, the seed was further sifted of dust and other impurities. About 2,000 maunds of Bhit Shah seed were in all distributed among the four cotton growing Talukas of the propaganda area, viz., Hyderabad, Hala, Tando Allahyar and Shahdadpur. The germination from this seed has been excellent and zamindars who have sown it have expressed great satisfaction. Apart from having better germination, the zamindars report to have effected much saving in the seed rate. Usually they put 40 to 70 lbs. per acre but 20 to 25 lbs. of machine ginned Bhit Shah have been found to give sufficiently thick stand and 12 lbs. of hand ginned Bhit Shah were put in an acre with equally good germination.

In several cases seed was delivered at the zamindars' villages or at Railway Stations nearest to them. Seed depots were also opened at Taluka headquarters for retail sale. When germination reports of the first consignment got abroad there was great rush for the seed and the stock was exhausted immediately.

## 2. DEMONSTRATION OF IMPROVED IMPLEMENTS, THEIR MANUFACTURE AND DISTRIBUTION.

Village to village demonstrations were held with the Rajah, Orient, Monsoon, Meston and the Egyptian ploughs. In all about 100 villages and hamlets were thus touched. Moreover, big central demonstrations at the headquarters of all the eight Talukas were oftentimes organized wherein the departmental implements were worked side by side with the local ones. On the whole, Egyptian plough met with universal appreciation. Negotiations were therefore entered into with local firms at Hyderabad, Sukkur and Larkana to manufacture these ploughs and other selected implements. The carpenters of the firms were at first trained by the Departmental Officers and the firms were given all conveniences and instructions from time to time as to measurements of several parts, kind of wood to be used, etc.; these works are from time to time supervised with a view to see that the outturn is satisfactory as regards workmanship, material, daily output, etc.

Besides the Egyptian plough a demand has been created for several other implements, e.g., Scrapers, Clod crushers, Drill tubes, Ridging boards, Meston ploughs, Archmedian screws, etc. The following table will give an idea of the implements disposed of through the agency of this Department:—

Name.	Number sold.
1. Egyptian ploughs	500
2. Orient plough	4
3. Meston plough	3
4. Archmedian screw lifts	9
5. Drill tubes	7
6. Ridging boards	2
7. Scraper	2

In order to make the departmental implements still more accessible to the zamindars, two such depots, one at Bagerji in Sukkur Taluka and the other at Larkana, have been opened where iron ploughs have been stocked for the purpose of being let out on hire to those zamindars who cannot afford to buy them.

### 3. PRACTICAL DEMONSTRATIONS IN IMPROVED METHODS OF FARMING.

With a view to bring home to the agriculturists the superiority of improved methods of farming, small plots (varying from 1 to 3 acres) were secured from zamindars in the various Talukas and arrangement was made for their cultivation under departmental supervision with the following results :—

#### (a) *Drilling Demonstrations in Cotton.*

About a dozen plots had been secured on private fields to show drill methods, but owing to poor inundation season only 10 plots could come under actual drill sowing in Talukas Hyderabad, Shahdadpur and Tando Allahyar. The seed drilled in all cases was 27 W. N. cotton except about 1½ acres which was sown with hand ginned Bhit Shah for comparison sake. Many difficulties had to be combated in executing this practical side of work, deficiency of water being the most unsurmountable one. With every fall of river the water courses ceased to flow and consequently water from the plots was cut off. Besides two resowings had to be done in most of the plots on account of somewhat poor seed.

Notwithstanding all this, these plots at this moment present a marked superiority over the adjoining broad-casted fields. Visitors and neighbouring agriculturists have been greatly impressed by the contrast.

#### (b) *Practical Demonstrations in Rice Cultivation.*

Larkana and Kambar Talukas of North Sind are chiefly rice growing tracts and about 10 plots (of area varying from 1 to 3 acres) were secured from zamindars for practical demonstration, with the following improvements and advantages :—

- (1) Reduced seed rate *versus* ordinary seed rate.
- (2) Earlier transplantation *versus* ordinary transplantation.
- (3) Bengal variety *versus* ordinary variety.

The results have yet to be watched as the crops are not yet ready but following facts are obvious :—

1. *Seed rate.*—The ordinary seed rate is one maund per acre but the Department has demonstrated with half the quantity. So far the results are quite favourable.

2. *Early transplantation.*—The advantages of early transplantation are summarized as under, *viz.*—

(a) It secures the crops against premature fall or sudden diversion of the River which is well known for its caprices.

(b) It offers even distribution of labour regarding sowing in nursery beds, transplanting, harvesting, etc.

(c) It assures better yield and better prices.

(d) It enables earlier crops and this liberates the soil in time for dubari (second) crop.

3. *Bengal variety*.—The plantation of the Bengal variety is a new introduction. The results have yet to be watched, but Mr. G. M. Isani, Deputy Collector and a Zamindar of Garhi Yasin Taluka, claims that :—

- (1) It yields much higher than the local varieties.
- (2) It is delicious like the Sugdasi.
- (3) Its seed rate is only about one-fourth the ordinary rate.

#### *Combat with Crop Pests.*

Several enquiries regarding cotton pests have been received and general precautionary or available remedial measures have been suggested to the zamindars. Any extended programme of work in this direction cannot at present be executed for want of funds, or known methods of combating the diseases.

Complaints of rats doing damage to onion and wheat fields were received from several places. Help in the shape of supplying poison and demonstrating its use was immediately rendered. The zamindars have expressed great gratification.

#### *Taluka Development Associations.*

With a view to facilitate the work of intensive Agricultural Propaganda Taluka Development Associations have been deemed to be very useful organizations. Eight such institutions have been organized, one for each of the eight Talukas selected for intensive Agricultural Propaganda. They have all been recently put in motion with capital varying from 500 to 1,000. The Associations in North Sind are now busy in securing wheat seed indents for the ensuing Rabi and complying with them out of the stock of Pusa 12 secured already.

They have besides selected sites where implement demonstrations will be held in next cold weather.

Arrangements have also been made for the local manufacture of Egyptian ploughs through local mistries.

## CHAPTER VII.

## The land and its management in Sind.

By T. F. Main, B.Sc., Deputy Director of Agriculture in Sind, and Umersshah, Superintendent, Government Farm, Mirpurkhas.

Successful agriculture depends perhaps more upon the soil and the efficient management of it than on any other factor, assuming the existence of the essentials such as rain or irrigation and labour.

All the world over, and speaking broadly, poor crops are grown on inferior land,—and with certain striking exceptions, the land which was inferior 50 years ago is inferior to-day. In some countries it is possible to point to the definite improvement of the land over large areas. For example drainage worked a transformation in England about a century ago, and washing the soil with irrigation water in Egypt has definitely changed the character of the land, but in India it is difficult to point to any such wholesale improvement. Perhaps the only striking example has been the wholesale levelling of land in the rice tracts, but this must have been the slow work of centuries. In Sind the only example which comes to mind is the conversion of barren salt lands into rice lands, but this has been brought about more by the advent of irrigation than by the direct action of man. The bulk of the cultivated land in Sind is the alluvial plain, through which the Indus flows. Alluvial soil means soil formed from the deposit of soil particles which have been suspended in flowing water; and as is well known, the particles dropped from the water, vary with the speed of the water—the heavy or sandy particles being dropped from rapidly flowing water, and the very fine and clayey particles from slow flowing or stagnant water. This phenomenon is the explanation of the great variation in the character of Sind soils. Broadly speaking the soil of North Sind has a much superior texture to the soil of South Sind. This is because in the north the percentage of relatively large soil grains is high while in the south it is low. Now the former class of soil possesses certain very valuable characteristics, it is very retentive of moisture; it is easy to plough; clods are easily dealt with, and generally cultivation is a simple matter and good crops can be raised with a minimum of labour and water. It is here that the fine crops of “bosi” wheat are produced, i.e., wheat which receives no water during the period of growth. In sharp contrast, the fine grained soil of South Sind gives the cultivator great trouble. The plough turns up large clods which are difficult to break down into a seed bed. This in turn causes much loss of moisture from the soil which impedes a good germination. In order to produce good tilth a number of tillage operations is necessary, hence the cultivator after expending much energy, may still be rewarded with a bad “stand” of crop.

Apart from this broad distinction between the soil in the north and south of Sind, there is an almost infinite local variation. So much so is this the case, that there is a Sindhi proverb that the soil varies with the span of a partridge, and this is literally true, making an even crop an almost impossible achievement.

In addition to the character of the soil particles there is another very powerful factor affecting the physical character of the soil, and that is "kalar" salts, of which sodium chloride and carbonate are the most important. This kalar is found scattered throughout Sind. It is in fact not possible to point to a single village and say here, there is no kalar. But it is greater in some tracts than in others. It occurs in huge continuous areas or merely in small patches with every intermediate condition. When land is receiving irrigation then the exact location of the kalar-infected land can be recognized without difficulty—because being a soluble salt (or salts) it is carried up to the surface in the capillary water and deposited on the surface as the water evaporates. In this form the usual appearance is a dark powder. On lands which are not under regular cultivation there may be very little sign of kalar on the surface due to its distribution in the soil and sub-soil, and hence the zemindar sometimes receives a rude shock by the appearance of kalar when he begins to cultivate such a piece of land. In the case of kalar-infected land under cultivation there is a continuous process of the upward and downward movement of this salt. The irrigation water penetrating into the soil tends to carry it downwards while the capillary water has the reverse effect. Where the former predominates the kalar can be got rid of or at least kept in check, and this is the explanation of reclaiming kalar land by growing rice on it. It is not usually a permanent cure, as with the discontinuance of rice, there is a strong tendency for the kalar to rise again. If however there happens to be a stratum of coarse sand in the sub-soil, then the kalar which is driven down through this cannot readily come up again, owing to the weak capillary action in sand. Considered from the agricultural standpoint, the great consideration is the damage caused to the texture of the soil. The fine grained soils referred to above, have their stiff character immensely reinforced by kalar. In fact when a fine grained soil infected by kalar is watered the sequence of events is somewhat as follows:—The water remains on the surface for an abnormally long time as though it could not enter the soil. As soon as free water disappears from the surface, the latter passes from the muddy stage with great rapidity to the hard-crust stage—this is a matter of only a few hours. If such land is left alone for a day or two it becomes so hard that it can hardly be ploughed. Even when dealt with at the earliest opportunity after the surface is dry enough for cattle to walk upon, the plough turns up large rough clods, which soon become as hard as stones if not broken down immediately. When left untouched after irrigation, these stiff kalar infected soils assume a very hard surface like concrete which soon cracks in every direction, with large fissures about an inch or more wide separating the soil blocks. The general effect is suggestive of a cobbled stone surface—*vide* the illustration. With such a soil it is very difficult to prepare a good seed bed and secure a good germination. Owing to the rough clods the moisture disappears rapidly, and the general result is that sowing must be speeded up by leaving the land in a relatively rough condition. In such circumstances a good germination is practically out of the question. This is especially so with kharif crops because the soil moisture evaporates so much more rapidly in the months of May and June

than in the autumn months of October and November, when rabi crops are sown. Hence on kalar infected land, it is a common sight to see rough portions of the field where the crop has failed. On other parts the crop may be seen wilting or withering owing to excessive loss of moisture from the soil. Kalar is, in addition, of course directly toxic to plants where it is present in sufficient quantity to make the soil solution too concentrated with salts, but this is not the main effect of kalar in Sind, which as explained above, is physical. Subject to these great limiting factors of kalar and sand, the soil of Sind is of a very high quality. Where these two effects are not prominent it is possible to grow some of the finest crops in India, and the tree growth is also witness to the strength of the soil. Cotton crops ranging up to two bales per acre have been realized, as also rice crops up to 2 kharars (3,120 lbs.). The growth of fruit trees and roses is further evidence of the excellence of the soil.

In the management of Sind soil the great problem is the improvement of the inferior patches or blocks caused by the factors explained above. After this the prevention of exhaustion is the most important consideration in a tract of country where the manure supply is so scanty.

In dealing with the improvement of the inferior land, the aim should be to improve the texture of the soil. Apart from washing out the kalar into the lower strata as is done by the rice method of reclamation, the most effective procedure is to grow fibrous rooted crops like berseem.

Manuring with organic manures like cattle dung, has also a marvellous effect. In both treatments there is an addition of organic matter to the soil, and when this becomes incorporated and thoroughly distributed throughout the soil, the texture of the latter is transformed, and a piece of land, which formerly may have proved most difficult to cultivate owing to its stiff character resulting in huge clods when ploughed, after receiving this treatment, will behave in an entirely different manner, presenting little or no difficulty in cultivation, and breaking down into a good seed bed with a minimum amount of effort. In this connection it is interesting to note that the reverse process has also been observed. Thus some land at Mirpurkhas which has been greatly improved through berseem cultivation, gradually deteriorated after discontinuance of berseem, and became very stiff and difficult to cultivate. Certain plots (*e.g.*, D. 6) on the Experimental Farm at Mirpurkhas were so stiff and troublesome to work, that they were excluded from experimental use and assigned to fodder growing. A crop of jowar in the kharif manured with farm yard manure (5 tons per acre) and a crop of berseem in the rabi season have been the treatment for the last five or six years, and now the land presents little or no difficulty in cultivation, so greatly has the texture improved.

Unfortunately rabi water is too scarce and too much in demand for berseem to be used on a large scale in this way, but it is highly to be recommended that any other crop possessing a good fibrous rooting system should be tried whenever possible. This should preferably be a kharif crop, in which season the water supply is more plentiful. The most promising crop of this type appears to be Sawa (*Panicum miliare*),



and it has moreover the character of strong resistance to kalar, germinating in soil too much infected to permit of a good germination of almost any other crop. Another method of ameliorating kalar land is to dress it with silt taken from the clearance of canals. In this case care should be taken to see that the silt is of coarse grain.

Where the soil is inferior owing to too much sand, this can also be ameliorated by organic matter. Kalar can be turned to advantage by applying it to such sandy soils if the transport distance is short.

The maintenance of the fertility of the soil has not been a very urgent problem in Sind owing to the disproportion between the available land and the available irrigation, but in certain tracts where the pressure on the land is greater, this has long been a pressing matter. More recently it has become a live issue on the Jamrao canal where crops are grown frequently on the same land, the tendency being to avoid the inferior land. In the former case we have a good example of continuous cropping along the Riverisan tract of Hyderabad District. Here for example in the village of Hathri the holdings are very small. The people maintain the fertility of their lands in this part by cultivating them very thoroughly in the dry season and they also manage to manure them, at least sparingly, owing perhaps to the large head of cattle maintained to work the Nars (Persian wheels), as nearly all the land is "lift" in this tract.

On the Jamrao, the problem appears to be more difficult. Much of the land is flow and only the minimum head of cattle are maintained as the people grow as little fodder as possible in order to release more land for cotton.

Hitherto the chief source of manure has been silt taken from old canal banks. Green manuring is not in favour owing to the water supply being required for cotton and cereal crops, and experiments so far as they go, do not indicate any very striking effects from ploughing-in sand. It will be difficult to find a satisfactory solution of this problem on the Jamrao until rabi water becomes more plentiful. The cultivator will then have to choose between growing much wheat and exhausting his land, or restricting his wheat and growing berseem which will react favourably on the fertility of the land, both directly and indirectly through making it possible to maintain a larger head of stock. One thing which has been proved quite conclusively at Mirpurkhas, is that irrigated wheat cannot be taken frequently with profit on the same land unless manured, or unless restorative cropping is adopted.

No reference to the land and its management would be complete without a reference to tillage implements. These are dealt with in a separate article, but it seems desirable to say something here about the intelligent use of implements.

On all the stiff soils it is found that the plough turns up a very rough surface owing to the clods which are produced, whether the plough be a wooden or an iron one. Hence it is always desirable on such land to carry out an operation preliminary to ploughing, the object being to produce a broken surface of an inch or two on the top. Such a broken

surface acts as a mulch and keeps the under-soil in good moist condition so that when ploughed, practically no clods result. In comparatively light soils this can be done by a toothed harrow, but on the stiff soils of Sind the only bullock-drawn implement which does the work at all satisfactorily, is the disc harrow. This should be the smallest on the market, *i.e.*, three discs on each side of the driver's seat. The work done by this machine can be further improved by using a beam or plank to crush the small clods.

In practice however it may not be possible to precede ploughing in all fields with a disc harrow owing to the time absorbed, and hence where ploughing has been done as a first operation, the Cambridge roller is a most useful implement with which to break down the clods.

With the aid of these two implements and the ploughs referred to in article IV, it should generally be possible to deal satisfactorily with stiff land. As both of these implements are somewhat costly it is obvious that at present one cannot expect individual haries to purchase them, but Co-operative Societies should aim at keeping them for hire, and this arrangement would also facilitate keeping these machines in serviceable condition, as a society would be able to secure the services of a skilled mistri from time to time.



18. Soil cracking after irrigation—indicating its stiff texture.



19. A crop of Berseem—which greatly improves the texture of the soil.

## CHAPTER VIII.

## Fruit-growing in Sind.

By T. F. Main, B.Sc., Deputy Director of Agriculture, Sind, and Alimahomed Ulvi, B.Ag., Superintendent, Government Farm, Sukkur, and Mahomed Umar Khan Barakzai, Dp.Ag., Superintendent, Wheat Farm, Jacobabad.

Sind possesses conditions which are very favourable for the production of certain classes of fruit. There is a deep alluvial soil and a very sparse rainfall and much freedom from disease. The absence of rain in the North of Sind renders this tract most favourable to Date-growing where fruit can be ripened on the trees. The grape does not suffer from either mildew or anthracnose which devastate the Nasik gardens. There are none of the Loranthus parasites which are the curse of mango plantations in the Deccan and of all fruit trees in the Nilgiris. The Citrus group have no die-back which makes the cultivation of the Santra Orange (even at Nagpur) so unsatisfactory.

The principal adverse factors are the strong hot winds and the powerful sun. These necessitate shelter, but it has been demonstrated at Mirpurkhas and elsewhere that excellent windbreaks can be grown in a comparatively short time. For this purpose the Tali (*Dalbergia sissoo*) is perhaps the best tree.

At the present time the scope for developing fruit-culture is severely limited by the absence of perennial irrigation but several centres scattered through the Province have acquired a considerable reputation for fruit. The most important of these are noted in the margin. In the neighbourhood of Shikarpur there are upwards of a thousand acres under fruit of which dates and mangoes occupy the largest area. Then come oranges and pomegranates. Rohri is the most important centre of date culture in Sind. A strip of land about  $2\frac{1}{2}$  miles broad stretching along the left bank of the Indus and extending to Khairpur Mirs, a distance of 14 miles, is especially suitable for dates. But the date is cultivated in many other places in North Sind including Sukkur, Larkana and Kambar talukas, in addition to Shikarpur already mentioned.

At Tharushah and neighbouring villages in the Naushahro taluka of Nawabshah District the most important fruit is the mango, but this place has acquired a special reputation for its oranges, although the area is quite small, amounting to only some 30 acres.

Hyderabad grows a great variety of fruits including figs, grapes, guavas, pomegranates and apples (an inferior variety).

Fruit-growing is, of course, popular with well-to-do men who undertake it for luxury purposes. Such men usually keep their orchards in a bad condition, partly due to ignorance and partly because they are unable to secure good mahlis. They also like to have a diversity of fruit-trees and hence their gardens become rather non-descript. Fruit-growing as a business proposition, is carried on at Shikarpur and Tharushah, and date-culture at Rohri is a highly specialized industry.

Thus at Tharushah average good trees after the 6th year from transplantation are reckoned to yield from 300 to 400 oranges and there are at least 150 trees to the acre. If we make liberal allowances for bad seasons and poor trees, the produce per acre should amount to some 15,000 fruits. The average wholesale rate is Rs. 5 per hundred and thus the gross value of the crop amounts to Rs. 750, but in good seasons this may be doubled.

It is difficult to estimate what the net return to the grower is, because expenditure after the first year goes chiefly in labour which may be done by himself and family.

The chief problem of the grower is guarding his crop from birds and theft and harvesting and selling the produce. It is difficult for the grower to attend to this himself, and hence there is a common practice of selling the crop to a contractor several months (in April) before the produce is ripe. The grower thus escapes the risk of losing his crop and the trouble of watching and selling it. He, however, does not get good terms. The professional fruit contractors purchase the crop for about half its ultimate wholesale value.

Date-growing in Sind has reached a high degree of technical skill. First there is the selection of the offshoots or suckers, these must be carefully chosen with reference to their mother plants and their own root development. Detaching these from the parent plant is to be done with much care both as regards method and season. Irrigation has to be regular and assured. When the trees mature artificial pollination has to be most carefully carried out.

For this purpose each female tree should be visited eight to twelve times during the pollination season which lasts some five weeks from 20th February to 30th March.

A number of men are employed during this period to climb the male trees to collect the spaths containing the inflorescence. After the inflorescence has been removed from the spath it is cut into several portions which are passed on to the men whose business it is to climb the female trees and fertilize the flowers.

Then the development of fruit is to be watched. Five distinct stages are recognized corresponding to definite degrees of maturity.

The first stage is over when the fruit is about as big as a pea. At this time thinning is practised in order to enable the remaining fruits to develop. This takes place in May.

The third stage is reached when the fruit reaches its full size and the colour changes from dark green to various shades of yellow and red. Fruit picked at this stage comes into market in June, but it requires artificial ripening in jars containing a solution of salt, and certain varieties of date are specially suited to this treatment.

The fourth stage is reached when translucent spots containing sugar are visible on the surface. At this stage the crop may be picked and marketed without further treatment.

The fifth stage represents the final maturation of the fruit which has completed its ripening on the tree. The date at this stage is soft, sweet and fleshy.

Much knowledge is required in deciding at what stage to harvest the crop as some varieties cannot develop up to the fifth stage of maturation.

Date cultivation at Rohri affords an example of Hindu-Mahomedan

	Rs.	co-operation. The date gardens belong
1. Construction of a well ..	600	to the Mahomedans but the latter
2. Persian wheel water lift ..	80	find it necessary to call in the Hindu
3. A mud wall ..	200	contractor or Bania to assist them,
4. One pair of cattle ..	120	especially in dealing with the final
5. Purchase of 417 offshoots		stages of production and in marketing
of which 200 may be of the		the produce. The usual arrangement
valuable variety called		is to give the garden to the contractor
"Assuli" for which he may		on an annual or biennial lease. In the
have to pay Rs. 5 for each,		latter case, all items connected with
and 200 of other varieties		
and 17 males ..	1,200	

pollination, pruning-off old fronds, thinning, picking and handling the crop are dealt with by the contractor. The garden-owner however attends to irrigation. The profits to be derived from date-growing are large, but on the other hand the establishment of a date garden involves very considerable capital outlay. Thus a man who owns his own land and decides to establish a three-acre date garden will have to incur capital expenditure amounting to Rs. 2,200 as noted in the margin.

During the first four years he will get no return on the bulk of this capital, but by growing vegetables he can make his income cover his expenditure including interest at 10 per cent. From the fourth year the dates will begin to bear and vegetables will cease to be grown. His annual expenditure will then amount to Rs. 350 excluding his own labour, and the return from this garden is estimated by Mr. Alimahomed Ulvi as follows, assuming the rate of Rs. 8 per maund for fresh dates :—

Year.	Number of date bunches per tree.	Average weight of bunch per tree.	Yield of fresh dates in maunds per 3-acres.	Value of crop in rupees per 3-acres.
4	2	6	60	480
5	3	8	120	960
6	4	8	160	1,280
7	6	10	300	2,400
8	8	10	400	3,200
9	10	10	500	4,000

In subsequent years the yield may rise to 140 lbs. per tree. Good bunches weigh 20 lbs. and cases are reported of a single bunch reaching 40 or even 60 lbs. Thus some trees may yield five maunds of fresh fruit and if the variety is superior, such a tree will produce a crop worth Rs. 60.

These figures are, however, exceptional and for the purposes of calculation Rs. 4,000 is taken as the value of produce of a three-acre garden. For poorly managed gardens and inferior varieties the contract rate may be as low as one rupee per tree; but for such a garden as described

above the contractor would pay perhaps Rs. 6 per tree per annum to the garden-owner. This gives the owner a return of Rs. 800 per acre on his garden for an expenditure of Rs. 116 excluding his own labour. After the 10th year this expenditure however is much reduced, and the owner does little more than irrigate the garden once or twice a month and plough when required. The outturn from the garden however does not diminish, and date palms are said to continue to give good yields till they are 100 years old.

The contractors are very intelligent and thoroughly understand market conditions and many of them combine into unions for the purpose of controlling the market. The contractor may take the fresh fruit directly to his shop in the market or he may auction it through brokers. Surplus produce is converted into dry dates and stored.

In date-culture maximum profits accrue from the quality of the produce. Varieties like Assuli command much higher prices than do the ordinary varieties.

In the season, the market rate for fresh Assuli dates may amount to Rs. 20 per maund, while at the beginning and end of the season the rate may be much higher. At Shikarpur ordinary fresh dates, sometimes, are said to run up to Rs. 30 per maund in the month of August.

Similarly much distinction in the rate of dried dates prevails according to variety.

Name of Variety.	Rate in rupees per maund.	During the harvest season at Rohri
Assuli ..	20	the marginally noted rates for dried
Thothar ..	12	
Idulshahi ..	12	dates were prevailing in 1922.
Other varieties ..	10	

Mr. Cheema, Horticulturist to the Government of Bombay, has had samples of several varieties analysed and has found that according to composition the Idulshahi was superior to all other Rohri varieties—containing more edible matter and fewer seeds.

Sind will undoubtedly offer a very promising field to the enterprising fruit-grower when the perennial canals associated with the Sukkur Barrage, are constructed.

The Agricultural Department are considering the best means of preparing for that time, and a scheme for investigating the fruit-industry possibilities of the Province is now before Government.

At the present time there is a large importation of dried dates into Karachi from Overseas amounting to close on 20,000 tons per annum, worth approximately 30 lakhs of rupees; while the total imports into Bombay Presidency (including Sind) in the year 1920-21 reached 32,000 tons, worth nearly 80 lakhs of rupees.

In these circumstances and in view of the excellent facilities for date growing which will soon exist in Sind, it seems highly important to take steps to develop the date industry of Sind. At the present time the

prospective grower is faced with one serious difficulty. This is the short supply of offshoots of good varieties, and the high prices which these command. Thus Rs. 5 is not exceptional for an "Assuli" offshoot, and the rate sometimes goes up to Rs. 10. The offshoots of the very rare variety called Lohar may cost as much as Rs. 15 or 20 each. Offshoots of the common varieties cost one or two rupees each.

Considering that none of the Sind varieties are as good as the best imported varieties, it would be a very useful piece of work for the Department to import large numbers of offshoots of good varieties and plant them out in nurseries for sale to the public. There is ground for believing that offshoots of the best Mesopotamian varieties could be imported and sold for a figure much below Rs. 5 each.

Other promising lines of development are in connection with raisin-grapes, lime juice (from the sour lime) and oranges.

Both the orange family and the vine grow remarkably well in Sind and the Department produces a limited amount of good fruitstock of these as well as of mangoes, at Mirpurkhas for sale to the public. This is useful work because there have been many instances of the public being disappointed with the stock which they have imported from long distances at great expense.





20. Young Plantation of Santra Oranges at Mirpurkhas.



21. Sour Limes at Mirpurkhas.



22. Grafted Mango tree at Mirpurkhas.



23. Dates in bearing at Sukkur.

Department of Agriculture, Burma

BULLETIN No. 19.

THE PALM BEETLES IN BURMA  
WITH NOTES ON OTHER PALM PESTS.

BY

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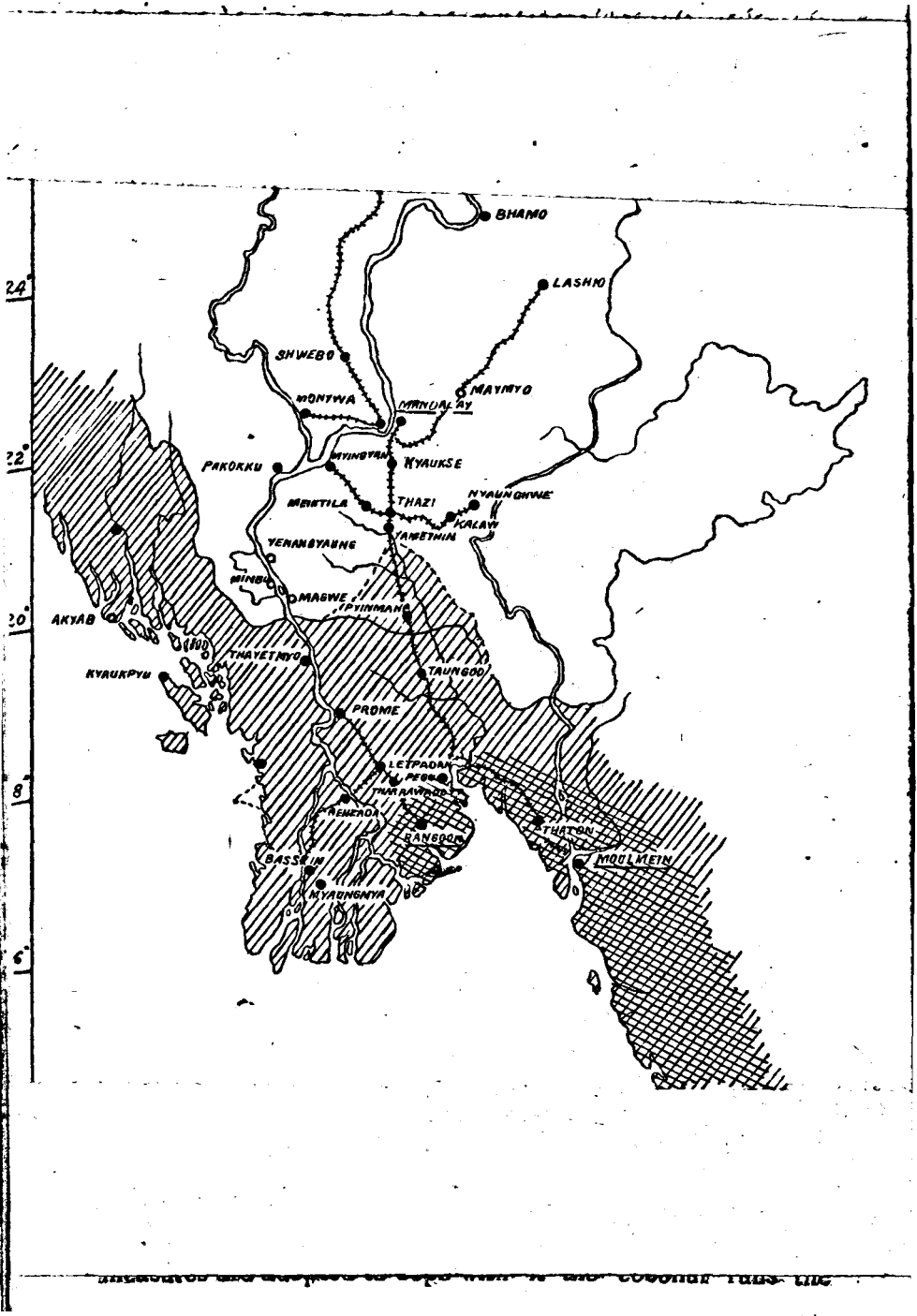
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# THE PALM BEETLES IN BURMA

WITH NOTES ON OTHER PALM PESTS.

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## INTRODUCTORY.

THE coconut is grown throughout Burma, although its cultivation on comparatively large scale is mostly confined to some of the sea-coast districts. The cultivation in many villages in the interior is by no means small. The crop obtained however is very much below the demand and coconuts of the value of about eight to ten lakhs of rupees are imported annually into the Province. There is ample scope of extending the cultivation and suitable lands are available all along the seacoast. But the cultivation, instead of extending is fast decreasing, chiefly owing to the ravages of insects, of which the rhinoceros beetle or the black coconut beetle is the most important. What the effects of the activities of this beetle have been, can be partly gauged by the following facts. Messrs. MacKenna and Shroff recorded in 1911, that prior to the appearance of this beetle in this province about 1895, the maritime districts of the Tenasserim Division were said to be able to meet the local demand for coconuts, but they were now very heavy importers from the Straits. An old resident of Thayetmyo informed the present writer that green coconuts which could be had there for three-quarters of an anna in 1891 were selling at eight annas in 1921. Nowhere in Burma at present a green coconut can be had for less than two annas, the average price being about four annas. Taking the circumstances as they are at present the coconut trees are a valuable asset to the people. Serious efforts should be made not only to save the existing trees but to bring about conditions which will admit of extension of cultivation. Attempts however at extending the cultivation or introducing new varieties of palms including the African Oil Palm, will be seriously hampered unless the pest can be checked. Its ravages have continued unchecked and the insect itself has been rapidly spreading into new districts, as will appear from the map (Plate I) indicating badly affected areas in 1910 and 1921. Unless vigorous measures are adopted to cope with it the coconut runs the

risk of disappearing altogether from the province. One has only to visit places like Pyinmana, Thayetmyo and Hanthawaddy to be convinced of the truth of this statement. The evil will not stop with the disappearance of the coconut. The beetles will then turn their attention exclusively to palmyra, *dhani* and other palms, which at present escape serious damage owing to the presence of the more favoured coconut.

Apart from the damage they themselves are capable of doing to the plants the beetles are known to carry and distribute germs of very bad forms of diseases like the bud rot, among the trees and thus have immense potentialities of further mischief not only to the coconut but also to the palmyra palms, in case an epidemic disease occurs. This is an additional reason why vigorous control measures should at once be adopted.

Unfortunately the owners themselves of the trees, through their ignorance of the life-history and habits of the pest provide it with ample breeding facilities. If they pay attention to the breeding places near their own dwelling-places, *viz.*, the heaps of rotting farmyard manure and of rotting straw and dead palm stems, the question of controlling the pest is at once solved. A poster has been prepared for distribution in the whole province in order to draw the attention of the people to this fact.

The coconut in Burma suffers from the attack of four major pests which are the following:—

- (1) The rhinoceros beetle or the black coconut beetle (*Oryctes rhinoceros*, Linn.)
- (2) The elephant beetle (*Xylotrupes gideon*, L.).
- (3) The red weevil or the palm weevil (*Rhynchophorus ferrugineus*, Oliv.).
- (4) The palm leaf nibbling caterpillar (*Nephantis serinopa*, Meyr.).

Out of these the rhinoceros beetle is the worst and is principally responsible for the death of the trees as it bores and kills the growing top of the stem. It has been under observation in Burma for a long time. A cultivator's leaflet (No. 17) was issued in 1909 and a bulletin (No. 4) by Messrs. MacKenna and Shroff in 1911. The present writer joined the Burma Agricultural Department in 1920, and took up the study in March 1921. The present bulletin gives the results of his observations both in the fields and in the laboratory extending over a period of about one and a half years.

The presence of the elephant beetle as a pest of the coconut was not suspected by previous observers. In fact

this beetle has not hitherto been recorded from this province. On investigation however it has been found to be widely prevalent, damaging the trees even in places where the rhinoceros beetle is not present. It has so far been noted to confine its ravages to leaves and leaf stalks. The ragged appearance of the trees in the form of trimming and punching of the leaves, gnawing of the leaves and leaf-stalks and breaking of the leaf stalks, is principally due to the activities of this beetle.

The red weevil where present usually follows the rhinoceros beetle and also probably the elephant beetle and frequently aggravates and completes the damage started by the latter. The three can hardly be separated. An account of the observations so far made in Burma on the weevil is therefore added.

The remedial and preventive measures which are advised to be adopted against the rhinoceros beetle will include the red weevil as well as the elephant beetle and if carefully carried out will be effective against all the three insects at the same time.

It has been considered useful to add a short account of the leaf-nibbling caterpillars which confine their ravages only to leaves.



## THE RHINOCEROS BEETLE (*Plate III*).

(*Oryctes rhinoceros*, Linn.)

### HOW THE RHINOCEROS BEETLE FEEDS AND DAMAGES THE COCONUT.

The rhinoceros beetle (*Plate III*, figs. 2 and 5) is well known to the owners of coconut trees in the localities where it occurs. It flies at night and bores the tops of palm trees by gnawing a large hole at the base of the heart leaf or of one of the outer leaves. It bores down into the stem and may go down as much as about a foot or even more. When the growing point or heart is damaged the tree ceases to grow and bear, gradually dwindles away and ultimately dies. Repeated attacks hasten the end. Frequently the beetle gnaws across the unfolded and unopened central leaves and such leaves on opening look to have been trimmed or punched (*Plate II*). The beetle primarily bores these holes simply to feed by cutting away and chewing the fibres and extracting the juice from them. The chewed-up loose fibres sticking out of the holes proclaim its work. Serious consequences however follow. The holes being large, up to about  $1\frac{1}{2}$  inches in diameter, the beetles find a shelter in them during the daytime. Several beetles are frequently found in the same hole which is gradually enlarged by the temporary occupants. All beetles are active and fly at night and therefore the same beetle does not probably continue to live at one place. Rain water lodges in these holes and sets up decay. When the pith rots it forms an ideal breeding place where eggs are laid and the resultant grubs feed. The end may be hastened by the red weevil or fungal and bacterial diseases. Gradually the crown falls off and the stem stands like a tall mast. The trees in infested areas present a poor appearance with scanty leaves and are in marked contrast to healthy trees with abundant spreading leaves and bushy crowns. These facts are matters of common observation and well known to the people.

### FOOD PLANTS.

Besides the coconut, the rhinoceros beetle is known to feed on various other kinds of plants of which the following are known to occur in Burma.

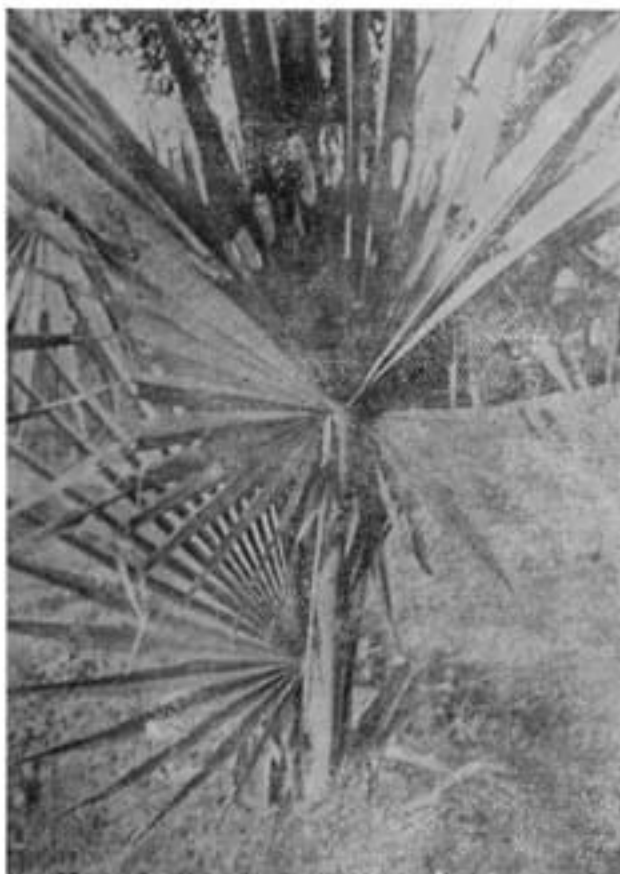
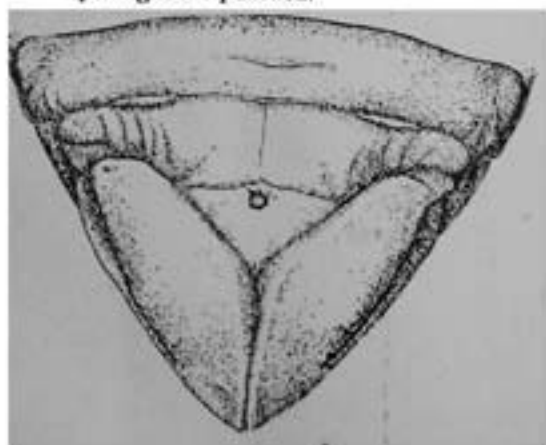
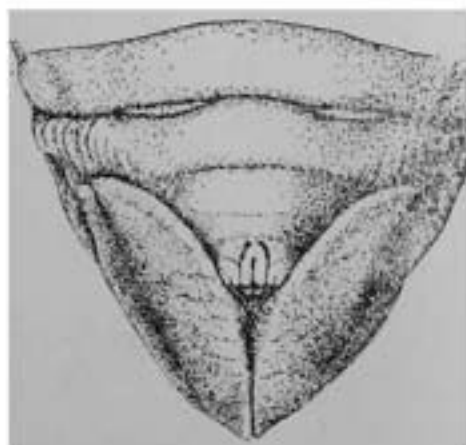


FIG. 1.

A young Palmyra Palm with punched leaf. The rhinoceros beetle does not eat leaves, but, while boring at the top of the stem, may gnaw through an unopened leaf which on opening looks punched.



♀



♂

FIG. 2.

Ventral surfaces of the hinder parts of male and female pupa.

The palmyra palm or the toddy palm (*Borassus flabelliformis*).—This is of great economic importance and is grown extensively in many districts, such as Magwe, Minbu, Pakōkku, Myingyan, etc., for toddy and jaggery. Its leaves are used for thatches and for making mats and *da-gauk-pha*, a kind of box in extensive use in Burma. The stem yields a very strong timber and the fruits are eaten both in young and ripe state.

The *dhani* palm (*Nipa fruticans*).—This also is of economic importance, its leaves being used for thatching purposes. A drink is obtained from it. It is of a more wild nature than the above and grows in the form of thick bushes in damp places, especially along the banks of the numerous creeks in Lower Burma.

The common wild date palm (*Phoenix sylvestris*).—This also is of economic importance. A toddy and jaggery are obtained from the trees. The fruits are eaten and leaves used for mats and other purposes.

The talipot palm, Burmese *Pe-bin* (*Corypha umbraculifera*).—It does not occur wild but is grown here and there in villages, apparently not for any particular purpose but as an ornamental plant.

*Pinanga* palms, of which three species occur, *viz.* *P. gracilis*, Burmese *Taw-kun*, in wild state from Chittagong to Tenasserim, *P. hexasticha* in the Pegu Yoma (Hill Range) and *P. hymenopatha* in Moulmein.

The Royal Palm (*Oreodoxa regia*) grown in the Horticultural Gardens, Rangoon.

The following palms which are not known to occur in Burma are recorded to be attacked by this beetle :—

*Elaeis guineensis*, the African Oil Palm ; *Cocos plumosa* ; *Corypha gebanga* ; *Cyphokentia samoensis* ; *Dictyosperma album* ; *Latania* sp ; *Livistonia chinensis* ; *Hyophorbe amaricanus* ; *Martinezia carryotae folia* ; *Metroxylon sagus* ; *Phoenix dactylifera*, the Date Palm ; *Roystonea* sp. ; *Sabal* ; *Verschaffeltia splendida*.

The betel nut palm (*Areca catechu*) is not attacked.

Besides palms, the beetle bores agave plants (*Agave sisalana*) and sometimes gnaws sugarcane stem.

The coconut however is liked by the beetle most and is preferred to the others. At present the damage done by it to other plants in Burma is hardly serious and in the case of the *Dhani* and wild date palms practically insignificant.

### THE LIFE HISTORY OF THE BEETLE.

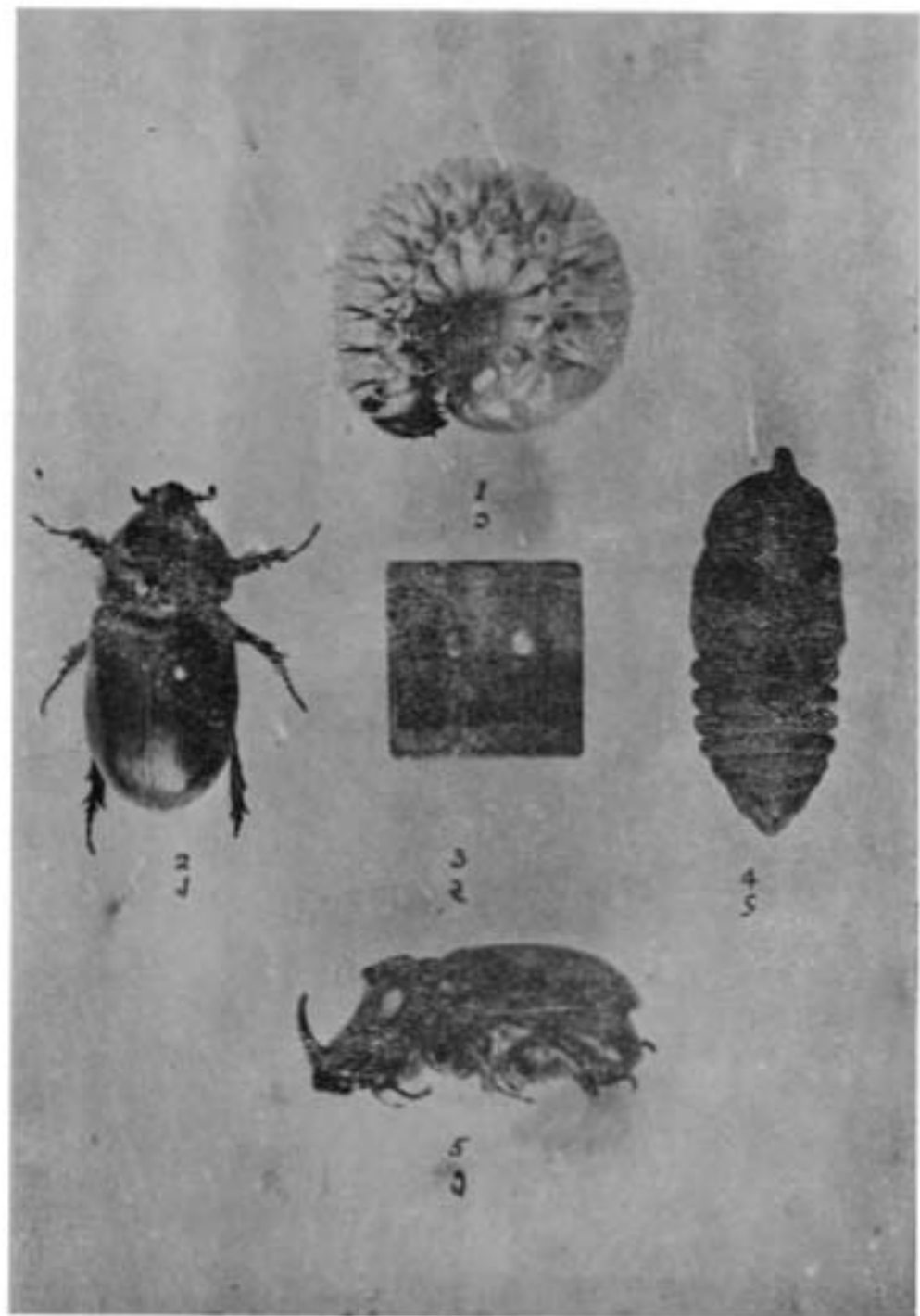
Although feeding on living trees in the adult state the beetle breeds, that is, passes the earlier stages of its life in decomposing vegetable matter or animal excreta. The known breeding places are the following:—

- (1) Dead trunks, whether erect or fallen of practically all kinds of palms and agave plants. When the soft parts inside the trunks decompose they form very good food for the young.
- (2) Rotting palm and agave stumps.
- (3) Coconut, coffee, cocoa and rice husks, leaves and fruit peels, etc., lying in heaps and decomposing.
- (4) Decayed dung of cows, horses, goats, sheep, etc. lying in heaps.
- (5) Decomposing rubbish of sugarcane mills.
- (6) Decomposing heaps of paddy straw and grasses of all kinds, whether in the thatch or lying on the ground.
- (7) Rubbish heaps of all descriptions containing decomposing vegetable matter or animal excreta.

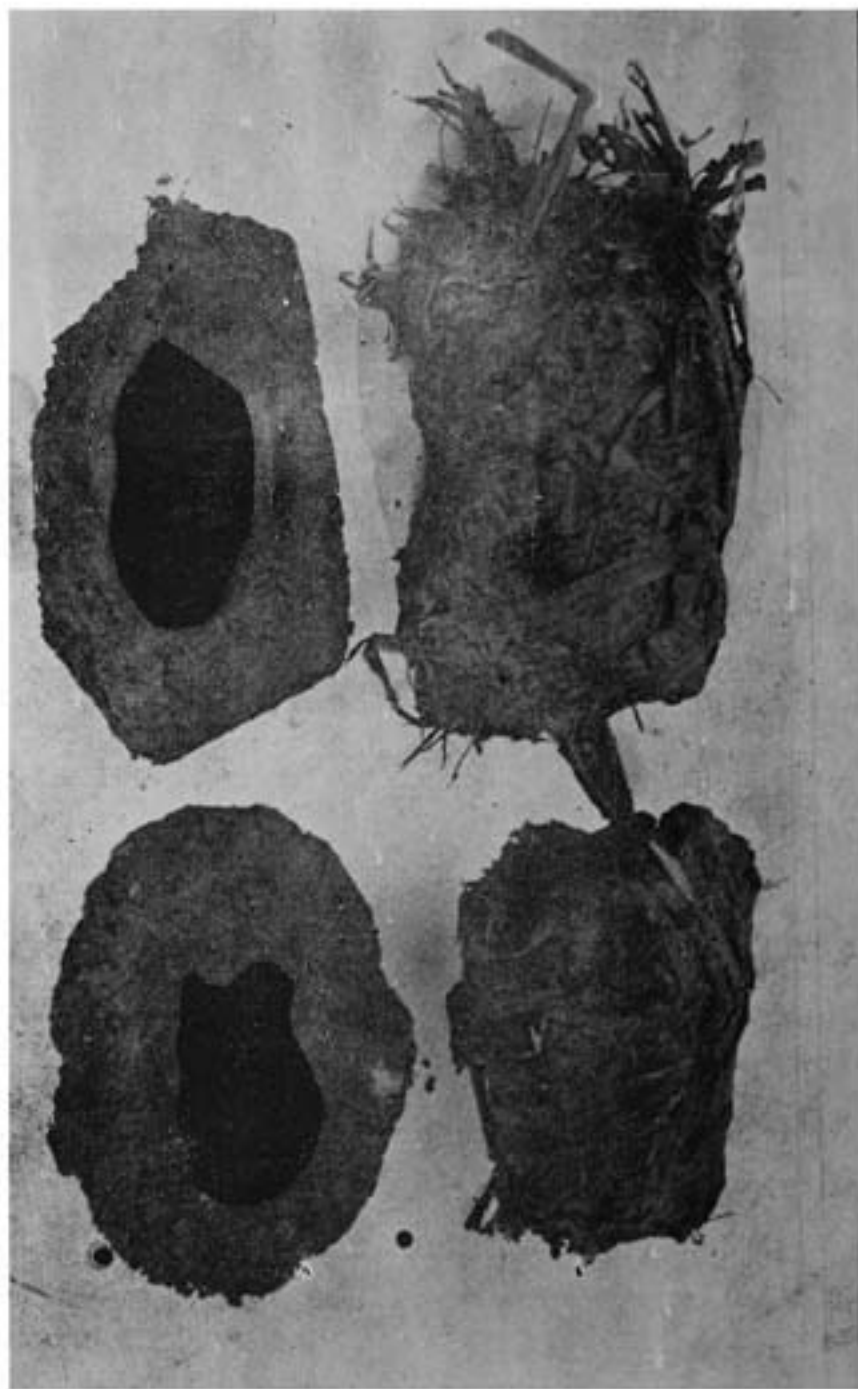
The adult beetle lays small round white eggs (Plate III, fig. 3) in these breeding places. From each egg a young one or as it is called, grub (Plate III, fig. 1 shows a grown up grub) hatches out and feeds on the decomposing food and grows. When grown the grub is a large white fat creature commonly known as *po-di-gaung* or *nwa-chi-po-lauk*. When full grown and full fed it moves down generally into the earth or into the denser layers of the heaps, if the heaps be large and transforms into the brown coloured pupa (Plate III, fig. 4) in an oval chamber which it prepares by agglutinating particles of earth or other material in which it has been living (Plate IV). When pupating in straw heap sometimes cocoons of twisted straw are prepared. The beetle (Plate III, figs. 2 and 5) emerges from the pupa but does not issue out of the pupal chamber at once. It rests there for a varying number of days before coming out, flying, infesting trees and depositing eggs. The development of the beetle in this manner from the egg through the various stages is described as a life-cycle. The cycle is repeated as in the case of all living creatures. As each female lays many eggs the number of beetles multiplies with every new cycle or brood.

### THE LIFE HISTORY AS OBSERVED IN OTHER COUNTRIES.

The details of life history, have been put on record by various observers. The writer's own observations in the neigh-



The Rhinoceros Beetle grubs (fig. 1) commonly seen in dung heaps, etc., hatch from eggs (fig. 3) laid by the beetle (fig. 2) and pass through the sleeping pupa stage (fig. 4) in order to turn into beetles (figs. 2 and 5). Fig. 5 is the side view of a male beetle showing the horn on the head. The egg when laid is oval and increases in size, becoming almost round before hatching.



Cocoons formed by the Rhinoceros Beetle grubs inside which they pass the pupa stage. The two on the left side are of agglutinated earth and the two on the right side are of twisted paddy straw.

bourhood of Pusa (Northern India) prior to 1911 were published in the Memoirs of the Imperial Department of Agriculture, Volume II, No. 10. There the beetles emerge in May-June and in smaller numbers up to about August and may live up to about November. Eggs are principally laid in May, June and July. The egg-stage lasts about 10 to 12 days, the larval stage about 10 to 11 months and pupal stage about 12 to 13 days. In Northern India therefore the beetle passes through one generation in the year.

In the Federated Malay States, Burkill thinks that the insect passes through two broods in a year. Copeland is of the same opinion as regards conditions in the Philippines. According to Froggatt, Government Entomologist, Australia, eggs are laid in June and July and the resultant grubs pupate and attain the adult stage in October but the beetles do not become active and remain in soil till the following May, there being thus only one brood in a year.

According to Meckie, in the Philippines, the egg stage takes 10 to 12 days, the larval stage 130 to 135 days, *i.e.*, about  $4\frac{1}{2}$  months, the pupal stage 30 to 37 days and the adult beetles begin their depredations soon after emergence. The insect thus completes its life cycle in about  $5\frac{1}{2}$  to 7 months and may have two generations in one year.

Leefmans records that in the Dutch East Indies, the egg-stage takes 11 to 13 days, the larval stage 63 to 126 days, *i.e.*, about 2 to 4 months and the pupal stage 19 to 27 days. The inactive stage of the beetle lasts for about 14 to 28 days and the adults live for about 4 to  $4\frac{1}{2}$  months. According to him, the minimum and maximum periods for a complete life-cycle of the beetle are about  $4\frac{1}{2}$  months and  $8\frac{1}{2}$  months respectively. Thus there may be one, two or even three broods in a year.

### THE BREEDING PLACES IN BURMA.

The principal and probably the only important breeding places in Burma are, farmyard manure heaps, rotting paddy straw heaps and dead palm (principally coconut) stems. The other two possible breeding places are the heaps of paddy husks near rice-mills and those of saw-dust near saw mills. But no breeding has been observed to take place in the mills the writer had the chance of examining. The paddy husks are either burnt, or thrown into water or in some places used as manure in paddy-fields. The sawdust is also periodically

cleared off. Both these substances take long to rot and as they are cleared before they have time to do so, they do not under the present conditions serve as breeding grounds.

Of the three breeding places mentioned, farmyard manure heaps are the most important. All over the villages these heaps are found, consisting chiefly of cattledung and paddy straw thrown out from cattlesheds and also of ashes, vegetable refuse and all sorts of rubbish commonly thrown on them. Generally these heaps are contiguous to the cattle sheds. As they are seldom used as manure they lie in an undisturbed condition for long periods, in most cases until they get converted into earth. They may be added to at the top or edges. Practically all such heaps have been observed to be full of the young stages of the rhinoceros beetle throughout the year. The following figures of collections made by turning over these heaps with spades will give some idea as to how common the insect is in these heaps. Between 23rd and 25th March 1921, two men in a random search of a total period of about six hours in the villages of Yinnyein and Theinzeik in Thatôn District collected 900 specimens, consisting of 27 beetles, 12 pupae, 835 grubs and 25 eggs. In all 30 heaps were examined either partly or wholly. Nine heaps which were thoroughly searched yielded 9 beetles, 12 pupae, 614 grubs and 25 eggs or a total of 730 and average of 81 per heap. The maximum number from an individual heap was 177 and the minimum number 1 (beetle). Two more visits were paid to Yinnyein Village and casual searches made on 3rd August and 26th December 1921. On the former date one man collected in about an hour 188 specimens, mostly grubs, by partly turning over 16 heaps including three small straw heaps. On the latter date by a similar search one man collected 371 specimens in about two hours from 15 heaps. Similar conditions have been observed to prevail in other infested places visited, *viz.*, Pyinmana, Nyaunglebin (by Mr. Clague), Hmawbi, Thayetmyo, Akyab and Sandoway.

The paddy straw heaps form extensive breeding places in the rainy season. No breeding takes place in straw as long as it is dry. The method practised in stacking or heaping straw renders it more suitable for breeding than it otherwise would be. The method of threshing paddy is to get the grains trodden out under the feet of cattle. The straw is thus broken and it is stacked in a loose condition by being heaped on the ground. On the top of the heap the rain water does not get sufficient flow and therefore soaks down to a depth of about half to one foot or even more, causing the entire top to rot.



The base of the heap also soaks water and rots. Rotting paddy straw is the most attractive breeding place and very much liked. Even very small heaps of this substance allowed to lie on the roadside are taken advantage of for this purpose. On the 3rd August 1921 at Yinnyeim 34 almost fullgrown grubs were found under a small quantity of paddy straw which would not form a load for a child of five and which was lying on the ground at the base of a mango tree. On the same date 32 young grubs were found under a handful of straw at another place. Under the straw left lying on the ground after the removal of a heap 33 grubs of varying sizes from fullgrown to young and one egg were obtained.

In order to show the conditions in the dead stems of the coconut palms a few typical observations are mentioned here. Similar conditions prevail in all places where the stems of dead and dying trees are allowed to stand or lie about.

*Shansu Village near Pyinmana, 28th December 1921.—*

The lower part about 9 feet of a dead coconut tree is standing. The upper part about five feet in length has broken off and fallen on the ground, apparently recently. The fallen portion is split open and 64 grubs, old as well as young, are collected from it. In the top of the standing portion one live female beetle, two eggs and 12 grubs are found.

*On the same date in a neighbouring village —*The standing base about 10 feet left of a dead coconut tree is observed to have been corroded all round just under the bark right down to the roots, the tough vascular central part being more or less intact. The corroded part is converted into dust (the season being dry), and is full of pellets of excreta of the grubs, of which only a full grown specimen is present, the others apparently having gone out as adults.

*Shansu Village near Pyinmana, 4th June 1922.—*One coconut tree has broken off at about two-thirds the height according to the statement of the owner. About 13 feet of the stem is still standing. The top is a rotting mass in which the following are found, *viz.*, 9 beetles (6 males and 3 females) 1 pupa and 29 grubs of the rhinoceros beetle.

One tree about 18 feet high has its central leaves dry but eight peripheral leaves are still green. The dry leaves are easily pulled off by a man who is made to climb. The bases of the leafstalks are observed to contain empty cocoons of the red weevil. The top of the stem is a rotting mass in which grubs of the rhinoceros beetle are found. The tree is therefore cut down and its top split open and searched. The following are found in it, *viz.*, 3 rhinoceros beetles (2 females

and 1 male), one egg and 26 almost fullgrown grubs of the rhinoceros beetle ; 2 palm weevils (1 male and 1 female), 2 grubs and 59 empty cocoons of the palm weevil. The cocoons are present mostly in the bases of the leaf stalks and a few just under the bark of the stem. Of the weevil grubs one is boring in the fresh part of the stem below the rotting mass and the other is inside a cocoon at the base of a leaf stalk.

#### OBSERVATIONS IN CONNECTION WITH THE BREEDING PLACES.

Paddy straw in wet and rotting condition is the most favourite food of the grubs of the rhinoceros beetle. In fresh cowdung heaps it is the straw which attracts the beetles for oviposition. If cowdung alone is heaped up no insect can bear the heat that is generated in the interior for some time.

Pure cowdung and droppings of horses, goats, etc., do not serve as food for the grub until they are at least several months old and partly decomposed. Heaps of these substances however form very good breeding places when they are old and decomposed, whether there be any straw etc., present or not. The grubs have been observed to feed and live happily in pure cowdung and pure goats' droppings which were converted into humus almost completely.

The grubs cannot live in very wet conditions. No breeding has been observed to take place in farmyard manure heaps which happen to lie in pits with excess of water in the rainy season. If the cowdung, etc., be in a liquid condition breeding becomes impossible. For this reason breeding has been observed to be going on on a larger scale in these heaps in the cold and hot weather than in the rains in Thaton and other places with heavy rainfall. In Pyapon District which is in the heart of the affected area the people say that the rhinoceros beetle occurs only in the cold and hot seasons.

Farmyard manure heaps, as already stated are the most important of all the breeding places. Observations go to prove that it is these heaps which enable the beetle to get a footing in new places. The pest has been spreading from the Lower to Upper Burma, *i.e.*, from the south to the north. Even casual observers will notice that the coconut trees in several stations south of Pynmana are hardly affected to the extent they are in the neighbourhood of Pynmana. The reason is that plenty of cattle are kept near Pynmana on account of

extensive cultivation carried on here. The beetle found ample breeding places in the cowdung heaps, multiplied enormously and now it has converted the coconut trees themselves into breeding grounds.

There are many coconut trees on both sides of the Pyapōn River all the way from Twantō to Pyapōn. The rhinoceros beetle is present here. But the coconut trees are hardly affected to the extent they are in Thatōn or Hanthawaddy except in places like Kyaiklat and Pyapōn where the Indians keep cows. In the villages the local people depend mainly on buffaloes for cultivation and keep very few cows or bullocks. No one keeps cowdung. The writer had occasion to visit Pyapōn in the rainy season only when the buffalo dung was observed to lie like a liquid mud. Abundant green grass being available it is hardly necessary to stack paddy straw to any extent in this district.

#### THE LIFE HISTORY AS OBSERVED IN BURMA.

The life-history and habits of the rhinoceros beetle were observed in the laboratory at Mandalay and in Yinnyein village in Thaton District. For this purpose this village was visited in March, August and December 1921. Materials for closer observation in the laboratory in the form of grubs, pupae, beetles and eggs, were collected from this village and also from Pynmana, Hmawbi and other places and kept under rearing at Mandalay. Thatōn has practically an equable climate throughout the year, being never very cold nor very hot. All the places in Burma which are badly infested by this beetle have more or less similar climate. At Mandalay however the hot and cold seasons are more pronounced, it being very hot in March—April, although the cold cannot be described as intense in winter, which again is not of very long duration.

At Yinnyein a few farmyard manure heaps were thoroughly searched on 23rd March 1921 and all grubs, etc., found therein picked up. In two of these heaps live pupae and fullgrown grubs were again present on 3rd August 1921 which attained the adult state in the laboratory in the first week of September. Supposing that eggs were laid in them soon after the first search in March the complete life-cycle is observed to take about five months.

No insect was found in heaps of dry straw in this village in March 1921. But on 3rd August 1921 grubs in all stages

of growth and eggs were common under wet and rotting straw. Oviposition in these situations certainly began after several showers of rain had fallen. The largest grubs found under the straw at the base of the mango tree mentioned above attained the adult state in the laboratory in the first week of September. Supposing that the eggs were laid in May, the period of the life-cycle is observed to be about four months.

In the laboratory at Mandalay the grubs which hatched from eggs laid about the first week of November 1921, pupated early in April 1922 and attained the adult state in the middle of the same month. The life-cycle is thus observed to take about five and a half months.

It would therefore appear that fresh broods occur normally about every four or five months. Some of the insects, however, are slow in development and in their case the period of the life-cycle is very much lengthened. Some of the grubs collected in March did not pupate before the middle of November and again some others collected in December did not pupate before June. The period of the life-cycle in these cases would be about eight to ten months. The number of grubs which developed slowly in this manner however was very few. Although the insect takes such a long time to develop into the adult state it should not be supposed that fresh broods occur only after such long periods. Eggs, grubs, pupae and adult beetles could be collected from the infested villages whenever they were visited, that is in March, June, August and December. Eggs were deposited in the laboratory at Mandalay in March, April, June, July, October, November and December. The grubs kept under rearing pupated and attained the adult state in the laboratory practically in all the months of the year. Breeding is therefore continuous and is going on throughout the year, the broods overlapping one another.

#### PROPORTION OF MALES AND FEMALES.

Males and females occur in about equal numbers. Between March 1921 and September 1922 altogether 199 adult beetles were collected and reared in the laboratory and of these 103 were females and 96 males. Out of 49 collected from the villages, 28 were females, and 21 males. Out of 150 reared in the laboratory exactly half were females and half males. Some more details are given in the statement below showing the season when they were collected or reared.

Number of females.	Number of males.	Collected or reared.	Season.
18.	11.	Collected, except 1 male reared.	Early hot weather, March 1921.
15	23	Reared ...	Hot weather, June 1921.
27	31	Reared ...	Rains, August-September, 1921.
13	7	Reared 11 females and 6 males; collected 2 females and 1 male.	Cold weather, November 19 21 to January 1922.
16	13	Reared ..	Early hot weather, March, April 1922.
9	10	Reared, except 1 female collected.	Hot weather, May-June 1922.
5	1	Reared ...	Rains, August-September 1922.

#### DISTINCTIONS BETWEEN MALES AND FEMALES.

♂ Adult male and female beetles can be easily distinguished by looking at the hind end of the body. In males this part is more rounded, smooth, hairless, and glossy and in females it is slightly tapering and clothed with brown hairs. The length of the horn on the head is not a sure guide. The horn frequently is not very well developed in both males and females and some females may have horns much longer than those of some males.

The sex of the pupa can be made out easily by the markings on the ventral surface of the hind end as illustrated in figure 2 Pt. II. The female pupa has a round circular marking on the surface in the centre on the last segment. In the male this marking is non-existent and the hind end of this segment enclosed between the lateral ridges is not pointed as in the female and is further marked by longitudinal indentations.

The sex could not be distinguished in the grub or egg stage.

## THE EGG.

The egg of the rhinoceros beetle is white with a tough membranous smooth shell. When newly laid it is oval in shape and measures about one-seventh inch in one direction and about one-twelfth inch in the other. With age it increases in size and becomes almost wholly round measuring about one-sixth inch in diameter before hatching.

Eggs have been collected from the breeding places in the infested villages. They have also been obtained from the beetles kept in the laboratory. For this purpose the females and males were kept in glass jars with wire-gauze covers. Moist earth, rotten cattle-dung and rotten paddy straw were provided in these jars and for food of the beetles fresh pieces of coconut leafstalks were supplied. The beetles bored into these leafstalks through the cut ends and frequently converted them into hollow tubes. The jars were emptied out and examined at frequent intervals and food, etc., changed when necessary. Care was taken to keep the females always provided with males. Many females were kept isolated in this manner. In the subjoined statement the record is given of only those from which eggs were obtained.

The female.	Date of attaining the adult state.	Eggs laid.	Date of death of the female.	Total No. of eggs laid.	First eggs laid how long after attaining the adult state.	Length of adult life.
Two females kept together.	1st week of June 1921	3 between 9th—12th July 1921.	1st week of August 1921.	3	1½ months	2 months.
One female	1st week of September 1921.	11 on 2nd December 1921.	20th March 1922.	11	3½ "	6½ "
Do.	Do.	4 on 26th Oct. 1921. 3 on 1st Nov. 1921.	11th Nov. 1921.	7	1½ "	2 "
Do.	Do.	4 on 22nd Nov. 1921.	3rd Dec. 1921.	4	2½ "	3 "
Do.	Do.	14 on 22nd Nov. 1921, 6 on 4th Dec. 1921.	7th Dec. 1921.	20	2½ "	3 "
Do.	Do.	9 on 8th Nov. 1921.	22nd Dec. 1921.	9	2 "	3½ "

The female.	Date of attaining the adult state.	Eggs laid.	Date of death of the female.	Total No. of eggs laid.	First eggs laid how long after attaining the adult state.	Length of adult life.
One female.	1st week of September 1921.	5 on 14th Oct. 1921.	26th Oct. 1921.	5	1½ months	1½ months.
Do.	3rd January 1922.	3 on 1st Mar. 1922.	7th Mar. 1922.	3	2 "	2 "
Do.	1st week of October 1922.	4 on 30th Oct. 1922.	6th Nov. 1922.	4	3 weeks	1 "
Do.	Collected 3rd June 1922.	2 on 20th June 1922, 13 on 26th June 1922.	5th July 1922.	15	...	...
Do.	Do.	2 on 20th June 1922, 2 on 26th June 1922.	10th July 1922.	4	...	...
Four females together.	Collected 23rd—25th March 1921.	33 between 8th—11th April 1921.	11th April to 5th May 1921.	33	...	...

None of the females reared in the laboratory commenced laying eggs before about three weeks of attaining the adult state. This is probably not the case in nature. The beetles reared in the laboratory left their pupal chambers 3 to 11 days after attainment of the adult state and in nature egg-laying probably takes place as soon as active life is commenced. At Pusa eggs were laid as quickly as on the fourth day. Leefmans records 20 days as the minimum period.

The number of eggs obtained from individual females under laboratory conditions does not probably indicate the number which a female is capable of laying in nature. The maximum number obtained at Mandalay as shown in the above statement was 20 (the 33 eggs obtained from the batch of four females might have been deposited by a single female). Leefmans has recorded 71 in the Dutch East Indies. In searching the farmyard manure heaps very commonly a number of grubs were found together within a short space and they were of such a uniform size that it would not be wrong to take them to belong to the same batch of eggs laid at the same time. Frequently almost entire heaps were turned over without meeting any grub but a number would be found together at one corner or within a small space at the top. In

one heap at Yinnye in the writer found 25 eggs and 60 newly hatched grubs at one place in March and he believes that these 85 eggs were deposited by a single female. The numbers of older grubs found together in similar situations in different heaps were 109, 83, 76, 40 and 30. It seems that eggs are laid in batches and each female probably lays several batches and therefore several hundred eggs during her long life which under laboratory conditions has been observed to extend up to a period of about  $6\frac{1}{2}$  months.

The eggs hatched in 10 to 17 days after being laid.

### THE LARVA OR GRUB.

The young grub is about a quarter inch long with a brown head and three pairs of well-developed legs. In appearance it resembles the grown-up grub (well-known as *nwa-chi-po*) which when fully developed measures about four inches in length and about one inch across the body. The head is brown and the body white, the hind end being darker. The series of brown spots on each side of the body are the breathing holes. The grub usually remains in a curved posture.

The eggs being deposited inside farmyard manure heaps, under rotting straw, inside rotting palm stems and in similar other situations the young grubs on hatching find themselves surrounded by plenty of food. They feed on these substances and grow. The grubs under observation took about three to four and a half months to become fullgrown. In the laboratory the grubs were fed on rotting paddy straw only. They lived and fed happily among this stuff covered with moist earth in glass troughs with wire-gauze covers.

### THE PUPA.

The pupa is yellow-brown in colour. It is found under deeper layers at the places where the grubs feed. The pupa of a fully developed grub measures about two inches in length and about one inch from side to side. Frequently however and especially in the case of the grubs fed under artificial conditions it is smaller in size. The distinction between male and female pupa has already been given. The pupal life has been observed to last for 16 to 13 days in the hot weather and 34 days in November to January.

The pupa produces a hissing sound by moving the segments in the hinder part of the body.



## THE BEETLE.

The beetle is dark-brown in colour, usually with a long or short horn on the head. Just when it casts off the pupal skin its limbs are soft, the colour is pale yellow and the hard wings which cover the back take a little time to develop. In about three days however all the limbs are properly developed and hardened, the colour changes to dark brown and the beetle is able to fly, feed and perform all the functions of adult life. It however frequently rests in the pupal cell for a varying number of days before issuing out. Why it does so is not known.

The size varies a good deal. The largest specimen in the Mandalay collection, a female, measures  $1\frac{7}{8}$  inch in length from the front of the head to the tip of the hind end, is  $\frac{1}{8}$  inch from side to side and has a horn  $\frac{3}{16}$  inch long. The measurements of the same parts for the smallest specimen, also a female are  $1\frac{1}{4}$  inch,  $\frac{5}{8}$  inch and  $1\frac{1}{2}$  inch respectively. The longest horn in the males of the collection is  $1\frac{7}{8}$  inch and the shortest  $\frac{1}{10}$  inch. In the case of the females the longest horn is  $1\frac{3}{8}$  inch and the shortest  $\frac{1}{2}$  inch.

The injurious activities of the beetle have already been indicated above. It shuns daylight and in the majority of cases passes the day in hiding in holes at the tops of coconut and other palm trees. While there it continues to bore and feed during the day as has been observed in the cages in the laboratory and also at the tops of young coconut and palmyra palms. The beetles are also found hiding inside the rotting mass in dead palm stems whether standing or lying on the ground, in farmyard manure heaps, rotting straw, etc. At night however all issue out and fly. In the laboratory all beetles attempted to escape from the cages at night.

None of these different situations where the beetles come to hide seems to be sufficiently attractive to be used as traps. The beetles spread and do not congregate at one place. The largest number found in a dead tree was 9 and that in a farmyard heap 8. In these two cases at least some of the beetles had pupated here and did not yet commence active life. In the numerous breeding places searched usually one or two and seldom more than three have been found in individual situations.

Ordinary lights, even bright strong ones, have no attraction for the beetles. The writer had occasion to use a powerful Storm-King gasolene lantern giving a bright white light for about 20 nights in the infested places but did not obtain a single beetle. On the 3rd June 1922 at Pyinmana eight beetles (males and females) captured the same afternoon were placed out in the compound after night-fall and a brightly

burning gasolene lantern hung up on a tree at a short distance. The beetles walked about and the first one took wing after about half an hour but it flew directly away from the light. The light did not seem to have any attraction for any of them. Occasionally however a beetle on wing may be influenced by lights. The writer on two occasions at Pusa while walking on road with lantern got two beetles which fell with a thud near the light.

Mating apparently takes place anywhere and any time during the day and night as will appear from the following observation. Twenty-eight beetles, 18 females and 10 males, collected in Thaton District between 23rd and 25th March were kept with moist earth in an earthen pot. On opening the pot on arrival at Mandalay on 28th March at 5-30 p. m. a pair was observed coupling. They did not mind being taken up with hand and were placed on moist earth in a jar at 5-47. At 5-49 the female began burrowing into the earth and the couple separated. All this time the male was on the back of the female and quite passive.

The beetles live quite a long time. How they were kept in the laboratory has been described under the section on the egg. They fed by boring into pieces of coconut leafstalk. The maximum period of life observed in the case of a female was 6½ months and in that of a male 6 months. The majority lived for 3 to 4 months, while some died even within a fortnight.

The male produces a low creaking sound by rubbing the hind end against the edges of the hard wing covers on the back.

#### COCONUT BEETLES AND DISEASES OF PALMS.

Several diseases of palm trees of fungal and bacterial origin are known and have been studied in different countries.

The bud rots are the most dangerous and most incurable of these diseases. They attack and destroy the growing bud or heart at the apex of the stem and the trees die sooner or later. In the Godaveri Delta in Madras a serious form of bud rot attacks the palmyra, the coconut and the betel-nut palms and considerable amount of money has been spent in trying to check it by destroying with fire the tops of affected trees so as to remove the sources of infection. Rhinoceros beetles and red weevils have been proved to spread this disease, in addition to other agents, *viz.*, tappers, birds and wind. Therefore checking these insects is considered as one of the methods of checking the spread of the disease.

According to Morstatt (1920) typical coconut bud rot is due to the attack of healthy uninjured palm by a bacillus that is favoured by soil conditions and injury due to insects and is probably spread by the latter. Secondary bud rot depends entirely on a previous disease or injury without which it cannot occur. The injury due to the rhinoceros beetle prepares the way for it. Either one or both the forms may occur in a country. In East Africa a primary independent bud rot and a secondary form due to the rhinoceros beetle are said to occur. In Samoa only the secondary form is said to be present (Rev. Ap. Ent. Ser. A IX, 103). Nothing is known about this in Burma.

The Red Ring or Root Disease of coconut palms prevalent in the West Indies is believed to be caused by a Nematode and to be communicable from one tree to another. Scavenging insects and palm weevils (and also palm beetles which are very readily attracted to decomposing trees for oviposition) are considered to be the means of transmitting living Nematodes or eggs from dead or dying trees. Prompt destruction of infested trees is advised.

The date palm disease known as "Doud" is considered to be due to the lesions caused by *Oryctes bispinosus* and another beetle. The disease may be the direct result of injury or due to secondary infection of a bacterial nature (Rev. Ap. Ent. X, 288.)

#### THE RHINOCEROS BEETLES IN OTHER COUNTRIES.

The popular name is given to the beetle on account of the presence of the horn on the front of the head like the horn of the rhinoceros. Different species, all however allied and with similar habits, occur in different countries. The various species recorded as rhinoceros beetles in different countries are listed below with the place where they occur. The common Burma species is *Oryctes rhinoceros*, L.

*Oryctes rhinoceros*, L.—India, Ceylon, Burma, the Straits Settlements, the Federated Malay States, Siam, Annam, Dutch East Indies, Java, Singapore, Sumatra, Celebes, Seram, Ambyona, Texas, Samoa, Seychelles, Formosa, Korea, Hongkong and Philippine Islands.

*O. nudicauda*—recorded from Minhla, Burma (Comotto, 1881-2) but is apparently rare.

*O. desertorum*, Arrow.—India, Persia, Arabia.

*O. elegans*, Prell.—Mesopotamia.

*O. preussi*, Kolbe.—South Sea Islands, New Guinea.

- O. cristatus*, Snell.—East Africa.  
*O. monoceros*, Ol.—East Africa, Zanzibar, Congo, Kenya.  
*O. Boas*, F.—East Africa, Zanzibar, Congo.  
*O. owariensis*, P. de. B.—West Africa, Congo.  
*O. nascicornis*, L.—Turkestan, Java, North West India,  
 South and South-East Europe.  
*O. trituberculatus*.—Dutch East Indies.  
*O. grypus*.—Morocco.  
*O. bispinosus*.—Algeria.  
*O. augias*, Ol., *O. colonicus* Coq., *O. insularis*, Coq., *O.*  
*pyrrhus*, Burm., *O. ranavalo*, Coq., and *O. sinner*,  
 Coq.,—Madagascar  
*Archon centaurus*, F.—Gold Coast.  
*Strategus aloeus*, L.—West Indies, British Guiana.  
*S. anachoreta*.—Trinidad.  
*S. quadrifoveatus*.—West Indies, Porto Rico.  
*S. titanus*, F.—West Indies, Jamaica, Cuba.

*Trichogomphus semilinka*, Rtz.—Solomon Island. Froggatt calls this the Solomon Island rhinoceros beetle and says that it feeds in the same way as the elephant-beetle. Three species of *Trichogomphus* are recorded from Burma but nothing is known about their habits.

*Camelonotus quadrituber*, *Oryctoderes latitarsis*, four species of *Pimelopus* and three species of *Scapanes*.—New Guinea.

It will appear therefore that many countries have to contend against the palm beetle. There have been various recommendations and trials made to control it. In some countries legislation has been resorted to for enforcing control measures and heavy expenses incurred to suppress the pest.

#### CONTROL MEASURES RECOMMENDED AND PRACTISED.

The control measures aim at diminishing the number of the insect and those in use among the people or recommended by scientific observers are enumerated below.

1. To deprive the insect of its breeding places—
  - (a) by clearing all rubbish and refuse heaps or burying such refuse under 8 inches sand ;
  - (b) by removing all dying or dead palm trees which are burnt or buried underground at a depth of not less than 3 feet or buried and covered under 8 inches of sand or cut into about 3 feet lengths which are split into four pieces longitudinally and left in dry places. The trees are recommended to be cut

low and covered with 8 inches of sand. Burkill recommends the use of explosives in disposing of tree stumps and says that four cartilages of blasting gelatine are sufficient for each tree. Logs used in making bridges are recommended to be stripped of the bark and their ends protected with tin and such bridges are recommended to be renewed after about nine months.

2. To search for beetles, grubs, etc., systematically in their breeding places and destroy them. In some countries large sums have been spent in this operation.

3. To use grub traps. Artificial pits are kept filled with decomposing vegetable matter to which beetles come for depositing eggs. At intervals the grubs, etc., found in them are killed either by turning over the heaps or fumigating them with carbon bisulphide or impregnating them with a poison, such as paris green or lead arsenate. In scrupulously clean localities where the beetle finds no other breeding places trap heaps are very successful. It is reported by Leefmans from the Dutch East Indies that in a garden cleared of all breeding places grub traps reduced the number of the beetles by 74 per cent.

4. To attack the grubs in their breeding places through other means, *viz* :—

(a) by impregnating the food with a poison, such as sodium arsenate ;

(b) by infecting them with a parasitic fungus, *Metarhizium anisopliae*. Much was expected of this fungus and various trials were made with it in different countries but without encouraging results;

(c) by introducing parasites ; more than one species of Scoliid wasps are recorded to be parasitic on these and allied grubs. But up till now they have not been reported to act as appreciable checks anywhere. For practical purposes, *Oryctes* grubs may be said to be immune against parasites ;

(d) by keeping and inducing predating enemies, such as pigs and fowls to prey upon the grubs. Dr. Friederichs states that in Samoa the semi-wild pigs kept by natives are one of the natural enemies and the Commission of Enquiry concerning Coconut Beetles in Samoa (1916), recommends making use of pigs on a large scale.

5. To prevent the beetle from being able to bore into the stem :—

(a) by filling the angles of the leaves with sand or sand

and arsenic. This does not protect the cabbage and arsenic is injurious to the tree ;

(b) by treating the crown with tar and petroleum ;

(The treatment injures the young bud.)

(c) by dusting the crown with Paris Green with the idea of poisoning the beetle. It is hardly of use as the beetle does not eat the fibres and it chews internal fibres which are out of reach of the poison ;

6. To decoy the flying beetle :—

(a) by means of light traps or brightly burning torches ;

(b) with substances having an attractive smell, such as fermenting toddy, fermenting rape or mustard cake or fermenting rice water kept in wide-mouthed vessels among the trees ;

(c) by growing alternative food plants, such as wild palms in the neighbourhood.

7. To treat the affected trees so as to cure them : First of all it is necessary to kill any beetle or beetles which may be inside the stem. Application of carbon bisulphide or kerosene oil injures the tree. In different places people pour sand or salt and sand or salt water.

Of the measures enumerated above legislation enforces the first two in some countries. As a matter of fact these two and under certain circumstances also the third measure are really efficacious when properly carried out. After visiting the Philippine Islands, Cochin China, Cambodia, Siam, Singapore, the Malay States, Ceylon and Madagascar, K. Friederichs who had studied the pest very carefully in Samoa, came to the conclusion that clean cultivation and the destruction of breeding places are the essential remedial measures in combating the palm beetle. Where this work is neglected even the natural enemies which include birds, rodents, Scoliid wasps and the fungus *Metarrhizium anisopliae* are not of much use in keeping down the numbers. (Rev. App. Ent., 1920, VIII, page 275.)

#### LEGISLATION IN FORCE IN SOME COUNTRIES TO CHECK THE RHINOCEROS BEETLE OR PREVENT ITS INTRODUCTION.

*Straits Settlements.*—The first legislative enactment against the rhinoceros beetle was in the Straits Settlements (Ordinance No. IV of 1890, amended in 1895). It is given by

*Copeland in extenso in The Coconut.* It enjoins the owner to uproot every coconut tree, dead or attacked by the beetle and either to consume it with fire or to bury it in the ground at a depth of not less than 3 feet or to keep it completely submerged in water. Similarly it is enjoined to remove from the premises and destroy dead coconut trees or stumps of coconut timber, rubbish heaps or other accumulations of dung, vegetable refuse or other matter likely to harbour or become breeding places for the beetles. Neglect or refusal to carry out these duties renders the owner liable to a fine varying up to twenty-five dollars. The work is carried out by Government and the cost recovered from the defaulter in the Court of Requests.

Various officials are given authority to have access to lands and trees for inspection. Provision is made for payment of compensation out of public funds to indigent owners, at the discretion of the Governor.

*Federated Malay States.*—Copeland mentions Enactment IV of 1898 in which similar provisions are made as in the Straits Settlements but all responsibility is vested upon the Government inspecting staff employed for the purpose. Agricultural Pests Enactment No. 13 of 1913, also has practically the same provisions, the owner being required (1) to clean his trees of beetles within one month of notice being served upon him, (2) to uproot and burn or bury below 3 feet, trees which are dead or attacked beyond recovery by the rhinoceros beetle (*O. rhinoceros*) or the weevil (*Rhynchophorus ferrugineus*) and (3) to destroy all breeding places; or the work is done at his expense. No compensation can be claimed for any loss caused by the application of the enactment but needy owners may be given compensation for trees ordered to be destroyed at the discretion of the authorities.

*Samoa.*—*Oryctes rhinoceros*, is believed to have been introduced into this island about the year 1909 in earth with rubber stumps brought from Ceylon. Its existence was detected on November 4th, 1910, near Apia, the port of entry. Very vigorous measures were adopted to check it. The proclamations and ordinances resorted to are referred to in the following quotation from a paper by Burkill (Gardens Bull. Straits Settlements, Singapore, I No. 6, December 1913):—

“On the 8th November 1910 the Government of Samoa issued a proclamation in vernacular to the effect that the beetles and their grubs should be collected, and promising a reward of one mark (36 cents) for every twenty beetles and the

same for every fifty grubs. Seventeen days latter a law was promulgated stopping coconut planting, ordering the cleaning up of all existing plantations, forbidding the using of coconut trunks for bridges and pig-styes and arranging for inspections. About £2,000 was the cost of this method of dealing with the pest up to the end of January 1912, and yet no satisfactory impression had been made on its numbers. Therefore on the first of February 1912, it was made compulsory to search for and destroy the insect. Following this there was issued on April 19th, 1912, a decree calling into being a commission with power to inspect and compel owners of coconuts to keep their estates clean, and to remove structures made of coconut trunks, or standing dead trees, at the owner's expense. Then on the 10th of May 1912, appeared an order requiring all able-bodied persons in the affected districts to turn out at six o'clock on every Wednesday to search for beetles and grubs, which were to be brought to the village headman, counted and destroyed by fire or hot water. Into this great holocaust passed the grubs of beetles which happen to be similar to those of *Oryctes*. Friederichs names them specifically: but their number is a matter for estimation. From the 1st of April 1912, to the 31st of March 1913, roughly, ten million grubs and a quarter of a million beetles were collected and killed on the island of Upolu; allowing for the grubs of the similar beetles, Friederichs puts down the *Oryctes* larvae destroyed as six million and the beetles as two hundred thousand, a nice little family originating in a few grubs imported in 1910 or possibly 1909.

To this figure has yet to be added the number of the grubs and beetles collected on the European plantations. On the estate of the Deutsche Handels-und Plantagen-Gesellschaft der Sudsee-Inseln zu Hamburg over the same period were collected and destroyed about 350,000 grubs and 23,200 beetles. Further, the number of insects trapped by the commission over the same period was 180,000 eggs, 776,000 grubs, 220 pupae, and 11,300 beetles."

Samoa came into British possession in 1914. The British Military Occupation of Samoa Proclamation No. 6, 1914, prohibits new planting or cultivation without permission in writing of the Inspector, appointed by the coconut beetle commission. Such permission is only to be given subject to the burning and destruction of all dead wood likely to provide breeding places for the insect. Proclamation No. 19 of 1915 orders that all labourers employed upon any plantation shall devote the working hours of the forenoon of every Monday



exclusively to the search and destruction of all stages of the coconut beetle throughout the whole of the infested portions of their land and a return shall be rendered to the Inspector by the owner showing the result of the search. The owner is held personally responsible for carrying out these measures. Contravention of these proclamations entails a fine.

*Ceylon.*—Regulations under the Insect Pest and Quarantine Ordinance No. 5 of 1901 require the owner to uproot and burn or completely submerge in water all dead coconut trees and to destroy living trees attacked by the rhinoceros beetle (*Oryctes rhinoceros*) or the red weevil (*Rhynchophorus ferrugineus*) or cut the portions attacked with the contained beetles, eggs and larvae and fill up the cavity with mortar, etc. Keeping of matter likely to shelter beetles is prohibited and also of dead coconut stems unless sawn into rafters for building. No manure may be left unused longer than four months.

The Plant Pests Ordinance No. 6 of 1907 sets up Plant Pests Boards with powers to require owners to carry out instructions regarding treatment or do it at owner's expense. All fallen and dead coconut trees are required to be burnt, unsplit coconut stems more than 12 months old to be removed from fences and unsplit coconut stems prevented from being further used in fences.

*British East Africa.*—The Coconut Beetle Ordinance of 1909 never came into force. The East Africa Protectorate Coconut Preservation Ordinance, 1915, was passed as a result of the investigation by the commission appointed in 1914. It provides for the inspection of all coconut growing lands. All trees dying or dead or attacked by insects (*Oryctes rhinoceros*, *O. boas* and *O. cristatus* are recorded as the rhinoceros beetles here) are required to be dealt with according to the direction of the inspector. Refuse heaps, dead coconut stems, etc., are required to be destroyed. Neglect or refusal on the part of the owner to carry out these measures entails a fine. The Governor in Council has power to make regulations regarding the construction of pit-traps for the beetles. The Governor may make such compensation as he thinks fit for trees ordered to be destroyed.

*Zanzibar.*—The Plantations Preservation Decree No 4 of 1913, provides for the destruction and disposal of dying, dead and infested trees and decaying vegetable heaps. An Inspector may enter any land and give orders for carrying out these measures or carry them out at the owner's expense. Compensations for trees destroyed may be paid according to the direction of the authorities.

*British Guiana.*—Under an ordinance to prevent and suppress diseases of plants and plant pests (1914), the Board of Agriculture has authority for inspection and treatment of diseases and pests among which the rhinoceros beetle (*Strategus aloeus*) is included. Orders have been issued for felling, dying and dead palms and for burning or burying them.

*Trinidad and Tabago.*—Plant Protection Ordinances are in force for the past several years and take notice of the rhinoceros beetle (*Strategus aloeus*) and the palm weevil or the gru-gru worm (*Rhynchophorus palmarum*).

*Seychelles.*—A bill is reported to have been prepared (1919) giving power to the Agricultural Department to eradicate the coconut beetle (*Oryctes rhinoceros*) at the expense of the owner from plantations not properly looked after and also to deal with the breeding places (Rev. Ap. Ent. Ser. A. VII. P. 483).

*Nyasaland.*—Coconuts are included among the plants which under the Plant Protection Ordinance No. 16 of 1912, are required when imported to be accompanied by a certificate that they have grown in areas free from diseases and pests.

*Tonga.*—Provision is made under law for preventing introduction and spread of the rhinoceros beetle.

*Fiji.*—By a Proclamation, No. 24 of 1913, importation of vegetable matter is prohibited from certain prescribed countries in order to prevent the introduction of the rhinoceros beetle (*O. rhinoceros*) except with special permission, inspection and fumigation.

#### NATURAL CHECKS AND ENEMIES.

Mention has already been made above under the section on control measures recommended and practised, of the existence of fungal diseases and insect parasites on the grubs in some countries. Experiments with them have shown that they are hardly of much use in controlling the pest. In the Philippine Islands a flying lemur (*Galeopithecus* sp.) is recorded to prey upon and destroy the beetles.

More than 700 grubs collected at different times from different infested districts in Burma were under observation in the laboratory. No parasite was observed. There were many deaths owing to the dry hot climate at Mandalay and artificial conditions of rearing, but no special disease could be noticed. When suitable conditions prevailed, for instance, during the moist rainy months there were hardly any deaths in the laboratory. The insect apparently thrives with hardly any

check in Burma. Adverse climatic conditions probably have a little effect on multiplication. For instance, during the rainy season it was observed at Yinnyein village in Thaton district that many farm yard heaps being soft and muddy breeding was restricted to some extent at this time. At Pyapôn the beetle is said not to occur in the rainy season.

Use of country pigs is recommended in Samoa for the destruction of the grubs. The writer and Mr. Clague tried some country pigs at Yinnyein but they would not even touch the grubs. Grubs thrown out in an open yard before fowls were soon picked up by the latter and crows. None of these birds however searches out the grubs from the breeding places.

In some places in Burma some people eat the grubs as well as the beetles. A Burman labourer at Hmawbi described that the dark hinder part of the grub was rejected and the rest of it eaten either in fried or boiled condition with salt. Nowhere however the grubs are collected and sold for this purpose as some other insects, for instance, crickets, are done at Mandalay. The number disposed of in this manner is apparently very small.

#### PREVENTIVE AND CONTROL MEASURES IN BURMA.

The measures necessary are to take care of the breeding places so that the beetles may not multiply. Their number will then very soon be reduced. The important breeding places are farm yard manure heaps, dead palm stems and rotten paddy straw.

All farm yard manure heaps, large and small, should be turned over with spade thoroughly whether any insects are found in them or not, at frequent intervals of about two months and never more than about three months at the most. All stages of the insect present in them should be killed by being crushed or cut or picked up and placed in hot water, or fed to fowls or thrown into deep water or buried in a pit not less than 3 feet deep in a hard soil, the pit being closed and thoroughly rammed down. The beetles should invariably be crushed or cut or killed by being placed in hot water. When it is possible to be done all heaps should be cleared off and distributed in the fields as manure.

With a little care these heaps can be converted into grub traps as are reported to be used with success in Samoa, British East Africa and Dutch East Indies. The plan would be to have as few heaps as possible in the village instead of each household having several indiscriminately located ones as at present and to turn over and search them at short intervals.

Paddy straw, thatching straw, *pyzung* (*Andropogon*) leaves, etc., rejected from cattle sheds should not be added to the farm yard manure heaps but should be kept separately and burnt when dry, at least before the rains commence.

Paddy straw for use as fodder should be stacked on a raised platform whether of earth or wooden or bamboo framework so that it may not soak water at the bottom and rot. Similarly, care should be taken by better stacking or providing cover, so that the straw may not soak water at the top and rot. No paddy straw should be allowed to lie about here and there and rot in the rainy season.

As soon as a coconut tree is sufficiently damaged, that is when its heart shoot and leaves are killed and it ceases to put forth any fresh leaves or flowering shoot it should be considered to have changed from a useful tree into a source of danger to other trees belonging to its owner and others and should be ruthlessly disposed of. The tree should be uprooted, cut into suitable lengths and either split into thin pieces, dried and used as fuel or thrown into deep water or buried under ground at a depth of 3 feet at the least. On no account should a dead palm stem (including palmyra, talipot and betelnut palm) or even a part of it, should be left standing or lying about on the ground.

The above are the essential measures necessary to be carried out over the whole infested area in order to be able to bring the pest under control and to keep it under control. If the carrying out of these measures cannot be ensured through persuasion or executive orders the circumstances demand that there should be no hesitation in resorting to legislation for enforcing them.

The writer and Mr. Clague visited Yinnyeik and Theinzeik in Thatôn district in March 1921, when the school boys and residents of these villages were got together, shown the insects present in farm yard manure heaps and explained how damage to coconuts could be prevented. Mr. Clague arranged to place Maung Po Su, District Agriculturist, to get the people to turn over their farm yard manure heaps in some villages in the Thatôn district. Mr. Shwe Zan Aung, Deputy Commissioner, called together the thugyi and gave them lithographed instructions regarding the measures to be carried out. Maung Po Su carried out the work for a short time and reported that he had destroyed 2,236 grubs, pupae and beetles. He gave it as his opinion that the work was not done satisfactorily and it would not be carried out satisfactorily unless there was somebody to see to it being done with threats of penalty in case of failure to comply with the instructions.

It may be mentioned here that the writer during his three visits to the Yinnyein village in March, August and December 1921, collected from the farm yard manure and straw heaps and disposed of about 1200 of the insect in different stages. Some more were destroyed by the efforts of Mr. Shwe Zan Aung and Maung Po Su. The result was that the thugyis and residents of this village reported less attack during the year although the work was by no means systematically carried out.

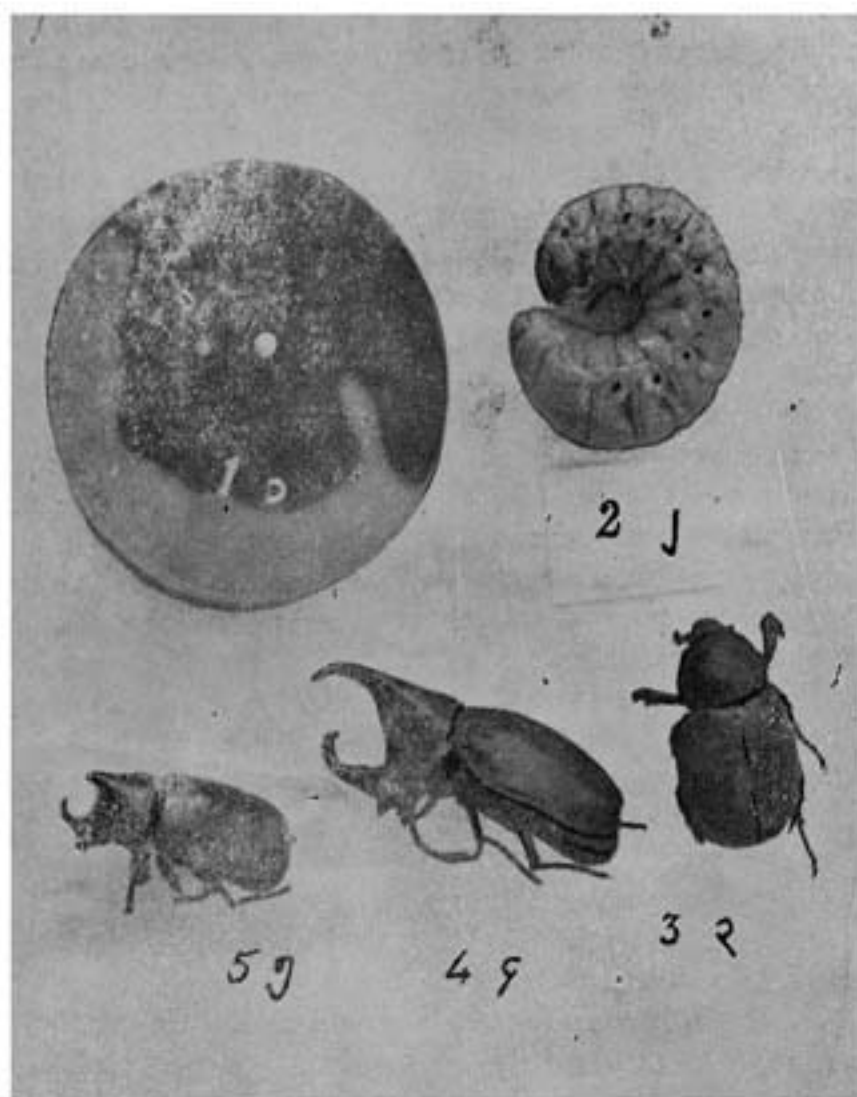
It would appear that in order to be able to combat the pest a good deal of propaganda is necessary to educate the people in the working and habits of the insect and it may be necessary to resort to legislation for enforcing the preventive measures. The educative propaganda is expected to disarm opposition to legislation. The plan of the educative propaganda would be the following:—

As more vigorous measures are required in the infested area in Lower Burma than in Upper Burma, the posters should be distributed as widely as possible in Lower Burma, so that they may be on view in all public places, such as offices, courts, and police-stations, at all railway and steamer stations, and in each village. The whole area comprising the Arakan Division and all the districts south of and including Minbu, Magwe and Yamèthin districts and southern part of the Southern Shan States, should be formed into convenient circles, in each of which a man will be placed. His work will be to visit all the villages in his circle at least once in three months and have all the breeding places treated or destroyed as necessary. He will at the same time have an opportunity of talking to the people about the pest. The farm yard manure heaps will be turned over probably easily but there may be some opposition to cutting down trees, although there should not be such opposition as the owners always know the trees which are irretrievably spoilt. Some pressure therefore may be necessary in the absence of a legislation. For the rest of the province, it will be enough if the posters are on view in public places and at railway and steamer stations and the leaflet distributed liberally.

The above measures may be supplemented by destroying the beetles which may be found at the tops of the trees. The only thing possible is to probe the holes with a pliable telegraph wire or even a pointed bamboo stick. If the beetle is pricked and injured it dies. It is advisable to plug the hole with sand and clay so that the red weevil, rain water, etc., may not have access into it. It is frequently not easy to collect the beetles

from the trees without widening the hole bored by the beetle and therefore inflicting further injury to the tree. Besides men are not always procurable to climb the trees especially during the rainy season when the stems are wet and slippery. Spasmodic efforts at collecting beetles from the tops of trees are often made by the owners. For instance, at Thayetmyo the *chetties* (money-lenders) pay four annas for each beetle extracted from their trees and are reported to have paid up to Rs. 25 at a time. Owners in Pyinmana pay one to two annas for each beetle extracted from their trees. In the Noakhali plantation at Akyab men are regularly employed to extract the beetles from the trees. The manager reported in 1922, that their efforts were not successful because no attention was paid to the beetle in the neighbouring villages. In August 1921, the writer declared a price of 1 anna for each living beetle at Yinnyein without receiving a single specimen.

PLATE V.



**The Elephant Beetle.** The grubs (fig. 2) found in dung heaps, rotten straw, etc., hatch from eggs (fig. 1) laid by the beetle (fig. 3). The grubs pass through the pupa stage (like the grubs of the Rhinoceros Beetle) to turn into beetles. Fig. 3 is a female beetle and figs. 4 and 5 are males showing difference in the development of the horns. The egg is oval in shape when laid, increasing in size and becoming almost round before hatching.

THE ELEPHANT BEETLE (*Plate V*).(*Xylotrupes gideon*, L.)

On account of the peculiar processes or horns on the thorax and the head of the male, looking when highly developed like a pair of curved tongs, this beetle is popularly called the "elephant beetle." It occurs in India, Burma, the Federated Malay States, Dutch East Indies, Indo-China, Queensland, New Guinea, New Zealand, Solomon Islands and the Philippines. It is curious that hitherto it has not been recorded from Burma where it is widely spread and is present throughout the year. In some localities in Burma where it occurs in large numbers and where the rhinoceros beetle has not yet been observed, for instance, Konzaung in the Mōn canals area in Minbu district, the experience of the people is that these beetles attack coconuts only in the hot weather commencing from about March. At other times in the year they are found on other plants, especially lady's fingers (*Hibiscus esculentus*) of which they eat the pods. It may be stated that coconut cultivation has been undertaken here within about the last ten years after the opening of the canals. The damage to the coconut takes the following form. The leafstalks are bored and gnawed across or along their length to some extent causing them frequently to break at the place attacked. The central unopened leaves are eaten or gnawed in the stalk causing them to break very often or exhibit trimming and punching on opening. Although the leafstalks are in some cases bored down to the base the beetles have not been observed to enter the stem. Therefore the trees are not killed as is done by the rhinoceros beetle, but the activities of the elephant beetle give them a very ragged appearance (*see Plate VI*).

In other countries where it occurs the elephant beetle is recorded as a pest of the coconut. Froggatt says that this beetle bores into the bases of the leafstalk, thence into the base of the crown of the palm where, if not checked, it will kill the terminal bud and destroy the tree. It has been recorded by more than one observer to infest the tender leaves at the crown of the coconut in Java. Burkill records it in the stem of Pinanga palm in the Straits Settlements. The elephant beetle is known to feed on many other plants besides coconut. The writer found many beetles on lady's fingers (*Hibiscus esculentus*) at Konzaung at the end of November. They fed voraciously on green lady's finger pods in the laboratory. At the same place they were also found on *Kasaw-bin* (*Cassia Sophera*) which grew wild in the jungle and of which the bark



seemed to be nibbled. The people report that the beetles are found on lady's fingers throughout the rains and winter and some times also on *Kon-ya-si-bin* or *Mya Sein* (*Parkinsonia aculeata*). In September a male was found feeding on bean leaves at Maymyo. Keuchenius records this beetle as abundant on *Murraya exotica* and *Poinciana regia* and to feed on the latex of hevea. Beeson found it on *Poinciana regia* in India, and Girault and Dodd on the same plant in Queensland. At Tezpur in Assam it has been observed damaging seed indigo plants by gnawing and stripping the bark (Proc. Third Ent. Meeting, Pusa, 181). Green has recorded it feeding on the foliage of *hevea* rubber in the Federated Malay States. It is also said to feed on the juice of damaged sugar cane and some times to gnaw the cane.

The life history of the elephant beetle is similar to that of the rhinoceros beetle. The breeding places are apparently the same, *viz.*, dung heaps and decomposing straw, etc. At Konzaung large numbers of the grubs were found under rotting straw at the end of November. The beetles laid eggs among rotting straw and rotten cattle dung in the laboratory in December. The periods of the stages are however not known yet. According to Girault and Dodd the whole life-cycle takes more than a year in Queensland, the pupal stage lasting less than seven weeks and being found between November and February. As far as can be made out in Burma the period of the life-cycle seems to be much shorter and breeding seems to be continuous and the broods overlapping as in the case of the rhinoceros beetle.

According to Leefmans, the grubs of this beetle injure the roots of the coconut and also of sugarcane and cassava in the Dutch East Indies. They are included among the cane-infesting grubs in Queensland. Recently a grub (apparently of this beetle which is still under rearing) has been sent in from Magwe as infesting groundnut under soil when the rain fall is scanty. All past records however show that the grubs habitually feed on decomposing vegetable matter in the soil and in Java, removal of decomposing rubbish has been considered useful against this beetle.

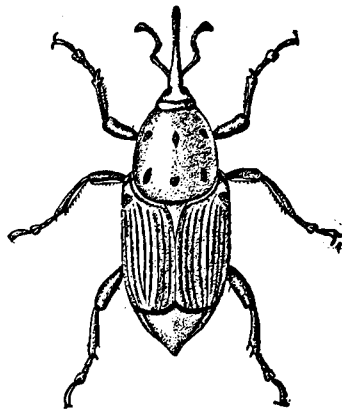
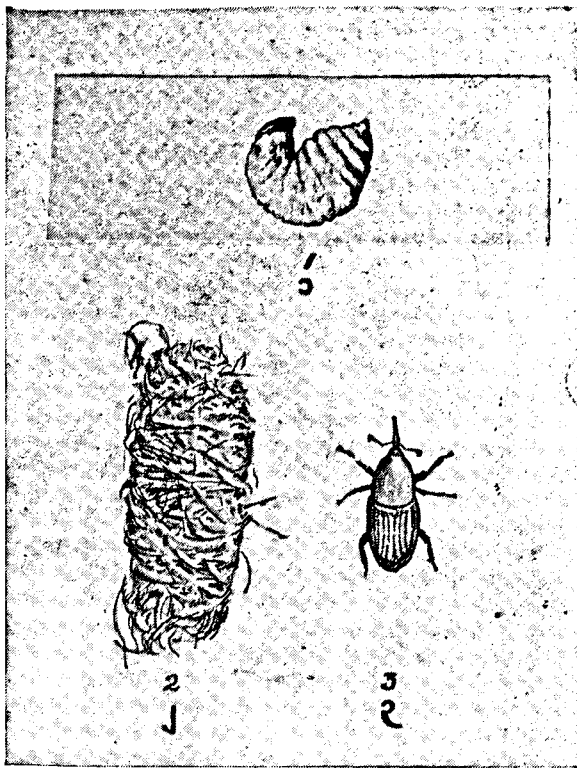
It would therefore appear that the measures recommended against the rhinoceros beetle are fully applicable against this pest too.

It may be possible to get at the beetle itself easily as generally it does not bore down very deep. Besides it is found some times in numbers on lady's finger, *kasaw bin* (*Cassia Sophora*) and other plants. Wherever present it should be collected and destroyed and never spared.



Coconut leaves damaged by the Elephant Beetle.

PLATE VII.



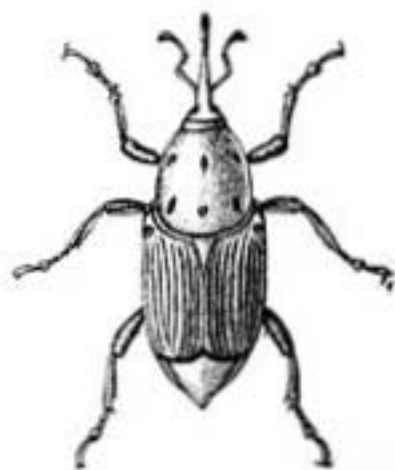
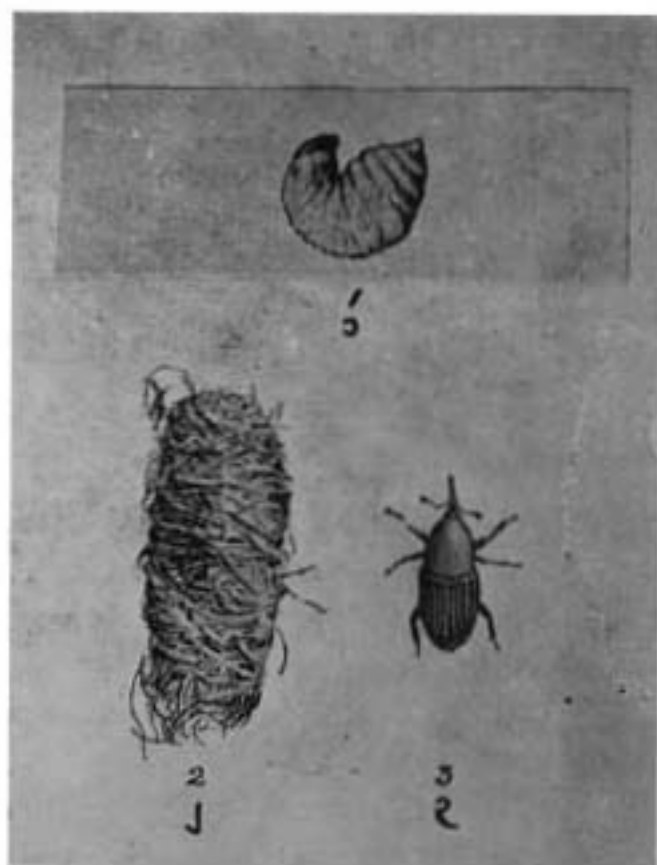
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The Red Weevil. The grubs (fig. 1) hatch from eggs (not shown) laid by the weevil (fig. 3). The grubs pass through the sleeping pupa stage inside cocoons (fig. 2) of twisted fibres before attaining the weevil stage (fig. 3).

THE RED WEEVIL (*Plate VII*).(*Rhynchophorus ferrugineus*, Oliv.)

The adult weevil (*Plate VII*, fig. 3 and 4) is a longish flattened insect having a long snout and red-brown colour with or without black spots on the upper surface. It is known to some people in places where it occurs. It is abundant at Pyinmana and also in Lower Burma where it is said to breed in *taw-kun* (*Pinanga gracilis*). As it lives in hiding and flies little it attracts less attention than the rhinoceros beetle. The weevil itself is incapable of doing any damage by feeding as is done by the rhinoceros beetle. It however seeks fresh living tissue to feed and deposit its eggs as the young require fresh palm tissue for food. The holes bored by the rhinoceros beetle afford easy access into such tissue at the very heart of the tree. Here it finds food as well as an ideal place for laying eggs. It takes full advantage of it and lays a good many eggs, as many as a hundred or even many more. The resultant grubs bore the crown all round and also down the stem and hasten the death of the tree. The weevil however may attack the tree anywhere, independently of the rhinoceros beetle, such as at the base or the middle of the stem if it finds suitable means of entrance or of oviposition. The holes gnawed by the elephant beetle in and at the bases of the leafstalks are vulnerable points where the attack of the weevil may commence. The trees when attacked by the weevil fare worse than at the hands of the rhinoceros beetle and are killed more quickly. But the weevil does not cause such wide spread damage as the latter. The weevil is known to live for two to three months during which period the female is capable of laying about 300 eggs. The eggs hatch in about four days in ordinary temperature. The shortest period during which the grub can grow to full size (*Plate VII*, fig. 1) is about a month. The full grown grub pupates in the affected stem inside an oval cocoon made by twisting the fibres (*Plate VII*, fig. 2). The whole pupal life inside the cocoon takes about three weeks. The adult weevil commences laying eggs soon after issuing from the cocoon. Therefore there may be fresh generations after every two months or so.

What usually happens is that when the weevil has access into fresh tissue it continues to live there and goes on depositing eggs for a number of days. This is why numerous grubs are found inside the same tree, which quickly succumbs to their attack. The weevil flies at night.



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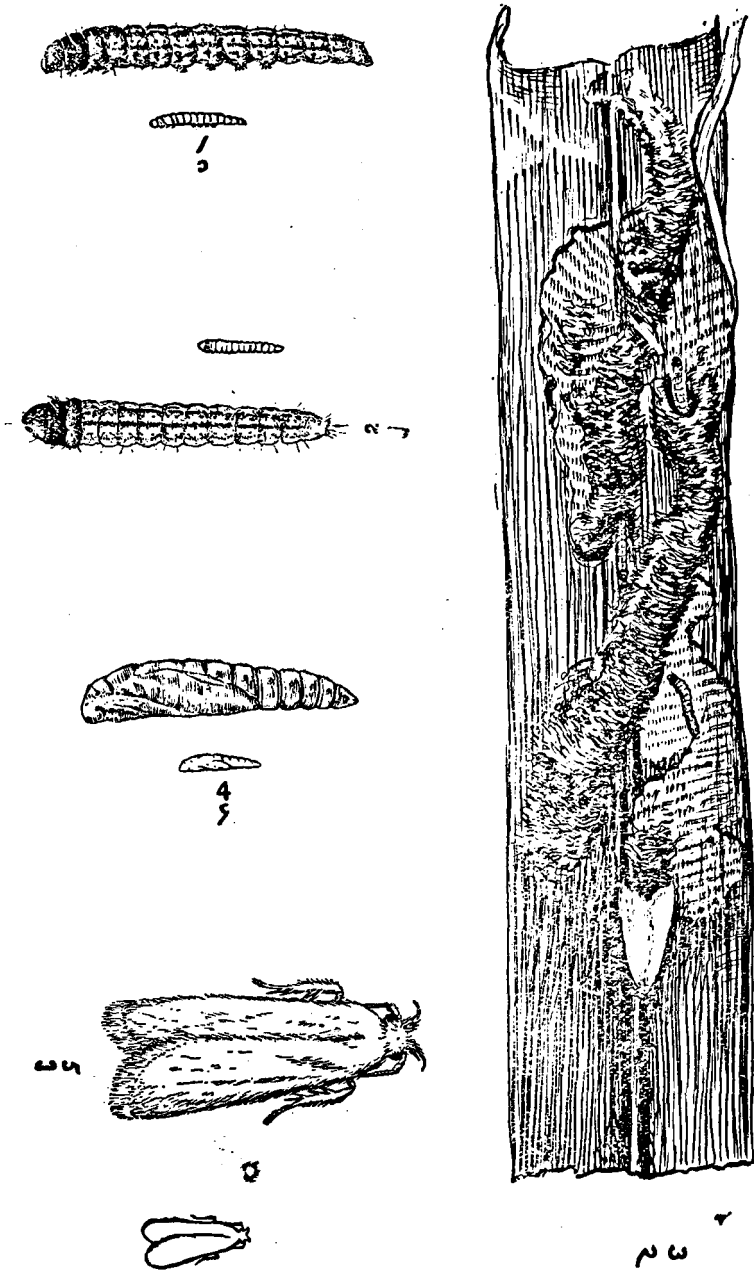
The Red Weevil. The grubs (fig. 1) hatch from eggs (not shown) laid by the weevil (fig. 3). The grubs pass through the sleeping pupa stage inside cocoons (fig. 2) of twisted fibres before attaining the weevil stage (fig. 3).

The palm weevil is practically as widely distributed as the rhinoceros beetle (*O. rhinoceros*) and has its representatives in Africa, West Indies and America. The food plants also are practically the same.

As the affected trees form the breeding places it is evident that if the control and preventive measures against the rhinoceros beetle are carefully carried out, they check the palm weevil also effectively. The legislation wherever in force against the former includes the palm weevil too.

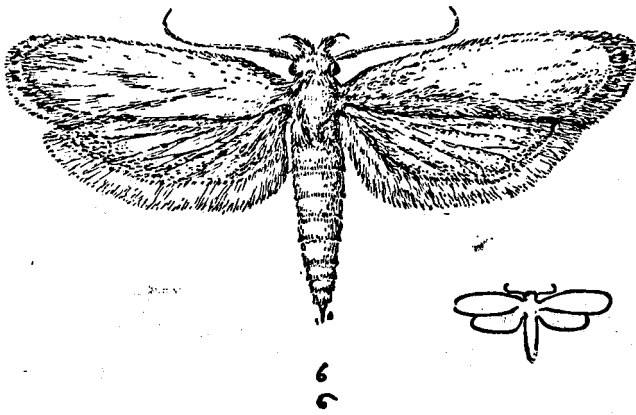
The grubs are eaten by Burmans in boiled or fried condition and are said to have a taste like that of boiled coconut milk.

PLATE VIII.



The leaf-nibbling caterpillars (figs. 1 and 2) nibble the surface of the leaf (fig. 3) and live under webbings formed on the nibbled surface. Later on they turn into pupa (fig. 4) and ultimately come out as moth (fig. 5, sitting posture and fig. 6, flying posture). The moth lays eggs from which caterpillars hatch. The smaller figures show natural sizes.

PLATE IX.



The moth of the leaf-nibbling caterpillar in flying posture.



## THE PALM LEAF-NIBBLING CATERPILLAR

(Plate VIII-IX.)

(*Nephantis serinopa*, Meyr.)

These caterpillars nibble the surface of the leaves. As a result of their feeding, the leaves dry. The attack commences from the lower leaves and gradually spreads to the upper ones. The pest is very active in the rainy season. In cases of bad infestation the trees are considerably weakened and succumb more quickly to the attacks of the rhinoceros beetle and the red weevil. The caterpillars alone however seldom prove fatal unless the attack is repeated in serious form year after year.

The pest passes its whole life on the plant. Eggs are very small and are laid on the leaves in crevices and furrows near the midrib. A single female lays about 200 eggs. The caterpillars (Plate VIII, figs. 1 and 2) which hatch from them feed by nibbling the leaf tissue and live hiding under webbings of their own excreta and dry chewed bits of leaf (Plate VIII, fig. 3). When full grown they pupate inside these webbings. The pupa (Plate VIII, figs. 4) is brown and from it the moth (Plates VIII-IX figs. 5 and 6) emerges after a few days. The period of the life-cycle is about five weeks from the egg to the adult stage. Fresh broods occur about every five to six weeks.

The pest is present in the whole of Burma and apparently in a worse form in Upper than in Lower Burma. It also occurs in India and Ceylon. In Burma it has been observed to attack the coconut, the palmyra, the betelnut, the wild date and the talipot palms, out of which the first named two suffer most. As the pest is present practically everywhere even on small wild date palms in the waste lands and jungles control measures become very difficult. Spraying with any kind of poison is out of the question. The only effective measure is to cut off and burn the first affected lower leaves. The importance of this measure will be apparent from the fact that a single infested coconut leaf has been observed to harbour up to about 700 caterpillars. The infested leaves therefore become prolific breeding grounds. If all co-operate in this method the pest can be readily controlled. In Travancore in southern India a special staff is temporarily engaged to see this measure being carried out. In Ceylon this insect is declared a pest by a proclamation dated 30th September 1922 under the Plant Pests Ordinance, 1907. Owners and occupiers of coconut plantations on which

( 36 )

any stage of this insect is present are required to burn light traps or defined forms of fires for at least two hours between 7 and 10 p.m. for ten consecutive weeks at the rate of at least three for every acre. The writer's trials with ordinary and gasolene Storm King lanterns in the Mandalay Farm at not very long distances from badly infested trees do not give much hope of success in this method.

## APPENDIX!

Since this bulletin was in print a fungus, characterised by the Imperial Mycologist, Pusa, as *Penicillium*-like, appeared in the laboratory at Mandalay in a lot of *Xylotrupes* grubs collected early in December 1922 at Konzaung in Minou District and killed off all the grubs. It was not found before either in the laboratory or in the numerous searches carried out among dung heaps, etc., during the last two years. It was tried on more than 300 *Oryctes* grubs in the laboratory on 24th January 1923 and all of them were killed by about 15th February. It was again tried on 20th February on 50 grubs all of which died by 6th March 1923.

The infected grubs die with these symptoms. Their activities cease and on death the colour loses its freshness and changes to yellowish white. The normal shape is retained to a very great extent but the whole body becomes stiff. Very soon a thick white bloom appears all over the body and in the course of a few days changes to dirty green in colour. The dead grubs do not rot (unless they happen to be covered with very wet matter) but gradually crumble away.

In the laboratory during the last two years *Oryctes* grubs have been kept and reared successfully in large glass troughs. Plenty of wet rotting paddy straw, old cowdung and earth are mixed and fill about half to two-thirds of the troughs. The grubs live in this material feeding on the straw and cowdung. In order to keep the material moist care is taken to have always a layer of wet straw on top of it. The troughs are provided with wire-gauze cover.

The fungus appeared in one such trough. The method of inoculation followed in the laboratory trials mentioned above was to take a handful of earth, etc. from this trough and mix with those in the troughs required to be infected. All the grubs (altogether in five lots) infected in the laboratory died with the characteristic symptoms.

A few *Holotrichia* grubs which went into hibernation soon after inoculation, resisted the fungus in the laboratory.

The fungus was given a trial under natural conditions in two villages in the neighbourhood of Pyinmana. The method of inoculation was as follows:—

A quantity of earth, etc., from the infected troughs in the laboratory was carried in a kerosene tin. Fresh grubs were collected in this tin and they soon barrowed into the infected material. After some time the contents of the tin were emptied and the grubs picked out and placed back in the following three situations with a handful of the infected stuff—

(1) An old coconut stump practically level with the soil in a compound in Shanzu village had 87 almost fullgrown *Oryctes* grubs feeding inside it. Practically the whole pithy part had been converted into a damp black powdery mass, the outer shell of the stump forming a sort of a trough. The grubs were kept for about 15 minutes in the inoculating tin (19th February 1923).

(2) One large mass of decomposing cowdung heaped up in an open place under but hardly shaded by a tree in Ywagauk Village. Some *Oryctes* grubs were present in it. About one hundred full-

grown as well as younger grubs, were added from the inoculating tin in which they had remained for about one-half to twenty hours. A quantity of wet straw was provided to the inoculated grubs and some infected stuff from the tin was spread over the entire heap. The heap was well covered by drawing up cowdung from the edges (18th February 1923).

(3) One dung heap having fresh and decomposing cowdung, paddy straw, etc. The grubs found in it were inoculated in the tin for about half an hour and also some grubs inoculated for about three hours were added. Infected stuff from the tin was mixed in the heap and also a quantity of wet straw placed in it (19th February 1923).

On examination on the 13th March 1923, all the grubs in (1) were found dead with characteristic overgrowth of the dirty green fungus, except one young one about one-third grown. The whole of (2) was searched and the following were obtained—

Four beetles, one pair mating (9 a.m.)

Five pupae, all about the situation where inoculated grubs had been placed and apparently developed from the latter.

Fifteen fullgrown grubs dead with the characteristic overgrowth of the fungus.

One such grub dead without fungus.

Fifty-eight fullgrown live grubs.

Thirty-two younger live grubs.

The following were obtained from (3) :—

Four beetles.

One fullgrown grub, dead with the characteristic fungal overgrowth.

Seventy-one fullgrown or almost fullgrown grubs; some of the inoculated ones had developed.

Thirty-five younger grubs.

This difference in the result was due entirely to the presence or absence of moisture required for the proper development of the fungus. The coconut stump retained moisture and gave the best result. The heap No. (3) was the driest of all and the fungus had no chance. The results of the heap No. (2) were not encouraging. It is not known how the fungus will work in the rainy season. At other times it apparently will not be effective under out-door conditions unless especial grub traps can be set up where the necessary moisture can be maintained. As far as can be made out under the present circumstances the fungus cannot be relied upon as an efficient instrument for fighting the *Oryctes* and *Xylotrupes* grubs.

Fullgrown grubs seem to be more susceptible to the fungus than younger ones.

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Looking up The Rice Research Station, Valley.

L—Laboratory under construction.

W—Working sheds

P—Pot-house

# STUDIES ON THE RICE PLANT AND ON RICE CULTIVATION.

## CHAPTER I.

### INTRODUCTION.

The growth of the rice plant, particularly in an area where transplanting is the universal practice, is so different from that of most agricultural crops that it seems obvious that a determination of the factors involved in producing a maximum crop will probably have to follow quite different lines from those which are used in the more usual crops. This has already been made clear by investigations in Spain, Italy, Japan, the Philippines and other centres, and by none more than those conducted in Madras by Harrison and his coadjutors. This being the case, it was proposed to initiate such a study of the rice plant in Western India, in that area where it is the principal crop, where transplantation is always practiced, and in districts where the conditions are so stable that about four-fifths of the total rice area can be planted with one and the same variety.

The work was commenced at a farm at Alibag, a station on the west coast of India, a few miles south of Bombay, in 1918, but it was transferred in 1919 to a newly established Rice Research Station at Karjat which lies at the foot of the Western Ghats between Bombay and Poona, and it is at this place that nearly all the work recorded in the present paper has been carried out. In order to compare the results obtained with others and to judge their general applicability, it will be necessary to describe the conditions as to climate and soil which prevail there, and to indicate the methods of cultivation which are used in this tract.

*Soil and Climate.*—The Karjat Research station is situated, as has already been stated, at the foot of the Western Ghats, with an average rainfall of 125 inches in the four months of June to September. The months of November to May are almost dry, and the characteristics of the rainfall during the rainy season are shown in the following table:—

Year.	June. Fortnight.		July. Fortnight.		August Fortnight.		September. Fortnight.		October. Fortnight.		Total.
	1st.	2nd.	1st.	2nd.	1st.	2nd.	1st.	2nd.	1st.	2nd.	
1919 ..	21·22	8·95	25·02	28·36	15·12	35·24	4·19	7·06	..	..	143 16
1920 ..	2·45	16·12	27·47	13·32	15·11	3·08	9·19	2·62	0·60	1·14	91·10
1921 ..	5·41	3·53	4·89	44·51	15·89	7·56	5·83	11·71	..	..	99·33
Average of three years ..	9·69	8·86	19·12	28·73	15·37	15·29	6·40	7·13	0·60	1·14	111·20

It will be seen from the above statement that June and July are the months of heaviest rainfall. The monsoon generally breaks in the first week of June and is heavy almost from the beginning. The embanked



rice fields are soon over-saturated and remain flooded for the greater part of the months from June to September. The rice fields are situated in the valleys between hills, and also on the gentle slopes of hillocks, extending further to the main drain carrying the flood water.

The tract is hilly and the fields receive soil by the wash from these hills. The soil varies from sandy loam to clay loam, and is yellow brown to dark brown in colour. It varies from six inches to eighteen inches in depth and overlies *murum* or disintegrated trap rock, and the trap rock itself. The chemical nature of the soil can be seen from the accompanying figures of analysis of a typical soil.

Loss on ignition	..	13.46	per cent.
Sand	..	62.32	" "
Lime (as CaCO <sub>3</sub> )	..	0.80	" "
Potash (as K <sub>2</sub> O)	..	0.14	" "
Phosphoric acid (as P <sub>2</sub> O <sub>5</sub> )	..	0.13	" "
Nitrogen	..	0.10	" "

The sub-soil drainage of the fields is excellent. In the lower valleys the soils are fairly deep and retentive and are cropped with *val* (*Dolichos lablab*) or gram (*Cicer arietinum*) after rice in the cold weather. The rice grown is either early, medium or late according to the high or low situation of the fields, and no facilities, except in exceptional cases, exist for irrigating the high lands during long breaks in the rains. The variety of rice known as '*Kolamba*' requiring about 150 days for growth and ripening, is a favourite with the cultivators and occupies almost all the low lying areas. The work recorded in the present paper has, therefore, been carried on entirely with this variety.

The temperature has a wide range and varies from 50 degrees F. in January-February to 110 degrees F. in April-May. The figures of average temperature in 1921 are given below for the growing period of the rice crop.

	Maximum Temperature° F.	Minimum Temperature° F.
June .. ..	89.7	76.6
July .. ..	87.5	74.2
August .. ..	85.7	74.5
September .. ..	Wanting	Wanting
October .. ..	98.0	74.

In spite of the heavy rain the days from June to September are warm. The skies are cloudy for a large part of the rainy season.

*Method of cultivation.*—Rice seedlings are raised in seed beds, which are, as far as possible, situated on high-lying rice fields or hill slopes. The seed beds are burnt with cow dung or branches,—the process known as *rab*\*—in the hot weather, and not manured with any other manure as is usual in many other tracts. Dry seed is sown broadcast in the seed beds at the commencement of the monsoon. The land is ploughed after sowing and the seed is covered with a brush harrow or a plank. The seedlings grow very fast, to about twenty-four to thirty inches in height, in three

\* H. H. Mann, N. V. Joshi and N. V. Kanitkar—The *Rab* system of rice cultivation in Western India—Mem. Dept., Agri., India, Chem. Series, Vol. II, No. 3.



**Woven frame used for equidistant planting in experimental plots.**

or four weeks, when they are uprooted and transplanted in the puddled fields in bunches of ten to sixteen seedlings, spaced twelve to fifteen inches apart. The crop is weeded once or twice as required and is harvested in October or November according as the variety used is early or late. The fields afterwards may carry a winter crop of pulse if the soil is sufficiently retentive. No cultivation of the fields is done in the hot weather, and the soil cracks very deeply at that time.

*The Rice Research Station at Karjat.*—The area of the Research Station is five acres, consisting of ten fields, and is enclosed by a pig-proof wire fence. A hill stream runs on the northern side of the estate which feeds the area with water during breaks in the rain. The fields are laid out into small plots each one hundredth of an acre in extent. Plots used for tests with manure are also embanked on all sides to prevent the mixing of water and also provided with separate arrangements for inlet and outlet of water. The fields are in good levelled condition and are fairly uniform in fertility.

*Plan of Work.*—With a view to study the behaviour of the rice plant and its productive capacity several series of experiments on the effect of each of the different factors of cultivation such as the age of seedlings at transplanting, the value of vigorous seedlings, spacing, puddling and manuring, etc., were laid out. In conducting this work every care to avoid experimental errors was taken. All plots were equal in area, seed of the same variety and ultimately of the same strain was used. All details of cultivation except the varying factors were the same for all the plots in each series. An equal number of seedlings was planted per bunch, and the distance between the bunches in the same plot was equalised by the use of square woven frames. Finally the number of bunches, which was always equal in all plots in the same series except in the spacing series, was counted. The results per acre are worked out to an equal number of bunches.

In 1919 the seed used was obtained locally. In 1920 seed of different strains was used for different sets of experiments and in 1921, when sufficient seed of the same selected strain became available it was used for all experiments. Thus the work of 1920 and 1921 has been done on supposed pure strains. During 1919 and 1920, in bunch planting, tillered and non-tillered seedlings were used in the same bunch, and each shoot was counted as a separate plant. This brought in a variant, as the yield of rice is affected by using tillered and non-tillered seedlings. Hence in 1921 all seedlings used were non-tillered and the word seedling means a single non-tillered stalk.

Counts on the tillering capacity of the plants were taken in the fields every week, on all the bunches in the central row of each plot, commencing after about three weeks from transplanting, till flowering. So also the height and number of leaves of three typical bunches in the same row were recorded every week. Finally the ear-heads in the central row of each plot and in the whole plot were counted in the yard before threshing. In harvesting, one row of bunches all round the plot was separately harvested, and its yield was not taken into account for comparison as that crop was generally more vigorous due to the extra space all round



Woven frame used for equidistant planting in experimental plots.

the plot. The remaining bunches were harvested together and kept for drying on mats so as not to lose any grain by shedding in handling the cut crop. Finally the ear-heads were cut off and preserved in bags until they were counted, threshed, and the yield weighed. As rats gave trouble in 1919, all the harvested crop was kept in 1920 and 1921 on a rat-proof stand. This rat-proof stand had its legs of glazed earth-ware pipes so that rats could not climb up the glazed surface. They are further obstructed by a tin slanting cap such as is used on cocoanut trees. Thus there is no possibility of any tampering to take place with the cut crop.

The seed-beds were burnt with cowdung *rab* and the material used consisting of cowdung, grass and earth was spread very evenly. The seed was sown broadcast with as much evenness as possible. Plots in the same series were operated upon as far as possible on the same day, and the planting was done almost always by the same men.

During the growing period of the crop a study of the life history of the plant from sowing to harvesting and its response to environment was kept in hand. After the harvesting of the crop the factors determining the yield were looked into with the help of the observations made on the standing crop, the figures of the counting of ear-heads, and their yield. It is proposed, therefore, to give an account of the observations made on the plant in the next chapters and then to discuss the factors which determine the yield of grain.

## CHAPTER II.

### THE GROWTH OF RICE SEEDLINGS.

#### (A). Germination.

According to the local practice seed is sown broadcast in the seed-bed at the commencement of the monsoon and is mixed with the soil by means of a wooden plough followed by the brush wood harrow or a light plank. The seeds in this process occupy different positions in the surface layers of the soil and their depth varies from merely lying on the soil, to being buried two inches beneath the surface. The time required for the appearance of the plants above the surface after the rains set in, varies very much, and depends upon the varying depths in which the seed is buried in the soil. Experiments carried on in pots gave the following results.

Pot.	Depth of seed.	Hours required for showing green shoots above the ground.
		Hours.
1	Seed sown on the surface of the soil	.. 120 to 240
2	Seed sown $\frac{1}{2}$ inch deep in the soil	.. 110 to 120
3	Seed sown 1 inch deep in the soil	.. 110 to 120
4	Seed sown 2 inches deep in the soil	.. 140 to 160
5	Seed sown 3 inches deep in the soil	.. 200 to 220
6	Seed sown 4 inches deep in the soil	.. } The plumule was not able to appear above the surface.
7	Seed sown 5 inches deep in the soil	.. }
8	Seed sown 6 inches deep in the soil	.. }

To ascertain the condition of the seeds in *those* pots where the seedlings did not appear, the soil was removed after ten days, and it was noticed that although the seeds in all cases had germinated, and the plumules had made considerable upward progress, the seedlings had begun to wither before the shoot had reached the surface.

The time required for germination of the seeds lying exposed at the surface of the soil varies very much. If there is enough rain, and the seeds become saturated with water, germination takes place along with those sown one to two inches deep in the soil. But when the rains are insufficient the exposed seeds on the surface may take eight to ten days for germination or may even be killed on account of want of moisture by long breaks in the rain. For proper germination of the seeds on the surface, there must be obtained a layer of water on the soil which may be had by impounding the rain water in the seed bed. Apart from the delay in germination and the extra water required, the seeds lying exposed on the surface are liable to the attack of birds. Even on germination, the shoots are likely to be damaged by strong winds or heavy rains as they do not easily become thoroughly rooted into the soil.

Seeds sown up to a depth of two inches and covered with soil are not likely to be exposed to dry conditions and hence germinate very readily taking not more than 110 to 160 hours for the shoot to appear above the surface, according to the depth to which they are sown. But a depth beyond two inches does not at all appear to be favourable for the growth of the shoot. Moreover deep sown seeds produce seedlings which are difficult to lift for transplanting, and many of them are liable to be broken in the process.

The effect of sowing seed at varying depths in the soil seems only to be that more or less time is required for the plumule to come above the ground. But once it has come up, its further growth does not seem to be in any way adversely affected by the depth of sowing. It is then purely dependent on the available plant food and soil conditions.

#### (B). *The Growth of the Radicle and the Plumule.*

Given sufficient moisture, the germ (plumule) appears in about forty-eight hours. In rice, unlike what is the case in many other cereals, the plumule emerges before the radicle. The plumule is white and tapering, but is about four times thicker than the radicle and is hollow in the centre. The radicle is white, long and solid.

*The Radicle.*—Tracing the growth of the radicle, it is seen that it gives rise to the primary root system which is composed of a number of fibrous and branching rootlets. Seeds sown at the surface of the soil, produce from three to eight fibrous roots, and these penetrate the soil, dragging to a very limited extent the seed with them. The primary root system is of a very temporary character, however, and a secondary root system is produced from the first node on the plumule. These second roots occupy a fixed level with reference to the surface of the ground and are just close to the surface of the soil. Hence if the seed had fallen on or very near the surface of the ground the two root systems come to lie close together. If on the other hand the seed happens to be

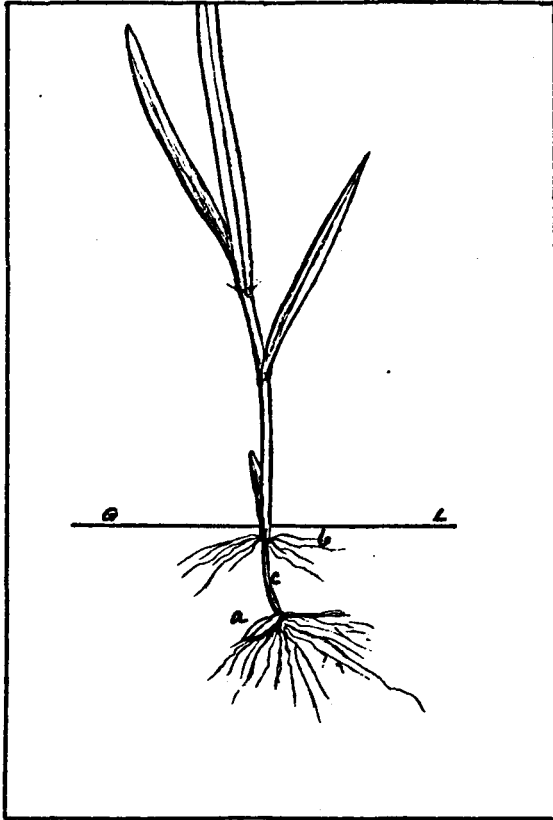
sown deep the secondary root system is produced from the first node of the stem after the plumule reaches the surface and produces the green shoot and the two systems hence lie wide apart connected by a white circular internode. All new roots which are produced during the life of the plant are produced from the portion of the stem bearing the secondary root system. Most of these travel into the ground and nourish the plant while others grow in an upward direction and project a few millimetres above the ground, (probably for aeration) where there is water in the seed bed. Similar roots, which might be called aerating roots, are also produced by the plants from the nodes of the stem which are above ground, if the stem is submerged under water.

The length of the radicle does not seem to bear any relation to the above-ground growth of the seedling. All grades of cases with short shoot and very long radicle to very long shoot and short radicle have been noticed. The growth of the radicle in the seed-bed seems in fact to be greatly affected by the physical condition and drainage of the soil. In sticky soil the radicle is small, while in friable soil it is long. In a badly drained and swampy seed-bed the radicle does not grow much and is very short. This fact was ascertained under laboratory conditions while studying the causes underlying the principle of sowing sprouted seed in the seed-beds followed in many parts of India. Dry seed was sown in two glass jars filled with surface pulverised soil, one of which was over saturated with water and kept always with a layer of water three to four inches above the soil surface. The soil in the other was kept only moist. Seeds in both germinated well, but those sown under swampy conditions produced extremely short radicles and long and thin shoots with narrow leaves. The fate of all these seedlings was not further watched, but it seems possible that the practice of germinating seeds before sowing may have to do with this adverse condition for the growth of the radicle in swampy and ill drained fields. Under these circumstances its growth is possibly hampered for want of oxygen as is evident from the experiments conducted by Isaburo\* in Japan. His work points out that in the absence of oxygen only the plumule develops and never the radicle. The growth of the plumule and the radicle in his experiment is shown below.

	Growth in length in millimetres.	
	First forty eight hours in wa er.	Next 24 hours in air.
Radicle .. .. .	0·10	11·55
Plumule .. .. .	10· 5	2· 6

*The Plumule.*—The plumule on coming above ground splits on one side, the growing shoot emerges, and on exposure to light develops a

\* Nagai Isaburo—Some studies in the germination of seeds of *Oryza Sativa* and *Zea Mays*—Joun. Tokyo College, Agri., July 1916.



**A RICE SEEDLING SHOWING THE TWO ROOT-SYSTEMS FORMED WIDE APART AS A RESULT OF DEEP SOWING.**

- (a)— SEED WITH THE PRIMARY ROOT SYSTEM.**
- (b)— SECONDARY ROOT SYSTEM AT THE FIRST NODE NEAR THE GROUND LEVEL.**
- (c)— INTERNODE.**



green colour. The torn white plumule forms a sheath round this shoot and always remains white. The shoot which is, of course, nothing but a rounded leaf in a rudimentary form then begins to grow and after about twenty-four to thirty hours unfurls the first blade. This blade, which is encircled by a *green sheath* in addition to the white sheath formed of the remains of the plumule, has, like all grasses, the growing shoot encompassed within itself. The general further growth of the leaves, one after another is similar to that in all grasses. The leaf sheaths are oval and consequently the stem of the rice seedling always looks more distinctly flat than round.

The growth of the plant is considerably affected by the conditions obtained in the seed-bed, such as the drainage, degree of moisture, space and light, and manurial treatment. It is proposed to show the influence of each of these as far as it has been studied.

(C). *The Preparation of the Seed-beds.*

Although in its later stages rice is an aquatic plant, it cannot stand waterlogging in the field during its early growth. The sites for seed-beds are, therefore, generally selected on high lying and well drained areas. The effect of a water-logged seed-bed is to give thin and pale seedlings with a very high death rate among them. As the seedlings grow they become able to withstand a larger and larger amount of water.

In a very large part of Western India including the area where the work under record has been done, the peculiar process known as *rab* is employed in preparing the seed-bed. This has been often described and studied\*, and consists in burning on the seed-bed a thick layer of cowdung, the branches of trees or even grass, during the three or four months previous to the sowing of the seed. This process has a very marked effect on the rate of growth of the seedlings. An experiment to measure this effect was made in a series of pots in soil treated with *rab* and in the natural condition. The seed used was of the same strain of rice, and the seeds were sown equidistant and at the same depth (one inch), at the rate of 576 seeds per square foot. The rates of growth in height and in the number of leaves are shown in the following table:—

Age of seedling.	†Height of plants.		Number of leaves.	
	Pot with <i>rab</i> .	Pot without <i>rab</i> .	Pot with <i>rab</i> .	Pot without <i>rab</i> .
	cm.	cm.		
Nine days .. ..	12	9	2	1
Ten days .. ..	15	9	2	1
Twelve days .. ..	22	10	2	1
Thirteen days .. ..	24	10	3	2
Fourteen days .. ..	24	10	3	2
Fifteen days .. ..	25	14	3	2
Twenty five days .. ..	53	20	4	3

\* H. H. Mann, N. V. Joshi and N. V. Kanitkar—The *Rab* system of rice cultivation in Western India—Mem. Dept., Agri., India, Chem. Series, Vol. II, No. 3.

† The height is measured up to the tip of the longest leaf.

These figures show that after twenty-five days the soil treated with *rab* had on the average given more than double the growth in height, and four leaves instead of three. More than this, the leaves were broader, and darker green in colour.

A very similar, though not an equal effect on growth could be produced by adding Sulphate of Ammonia as manure to the seed-bed as is shown by the following figures.

Age of seedlings.	Height of plants.			
	No manure.	Sulphate of Ammonia 200 lbs. per acre.	Sulphate of Ammonia 400 lbs. per acre.	Sulphate of Ammonia 600 lbs. per acre.
	Cm.	Cm.	Cm.	Cm.
Sixteen days .. .. .	7.8	15.8	16.4	16.5
Twenty days .. .. .	13.5	19.5	22.9	21.6
Twenty-four days .. .. .	14.1	20.4	23.9	23.6
Twenty-eight days .. .. .	17.9	20.6	28.1	27.4
Thirty-two days .. .. .	20.0	20.8	36.5	40.0
Forty-four days .. .. .	37.2	38.0	52.8	75.5

These results are of considerable interest showing how rapidly the manurial effect of small quantities of Sulphate of Ammonia appears to be exhausted. The attached graph illustrates this, and it is curious to see that after giving the plants almost as rapid a start as in any case, the effect of the smallest quantity of Sulphate of Ammonia seems exhausted in three weeks, while the effect of the larger quantities continues to the end of the experiment. The highest amount, however, went far ahead after thirty-two days.

(D). *Effect of Space on the Growth of Seedlings.*

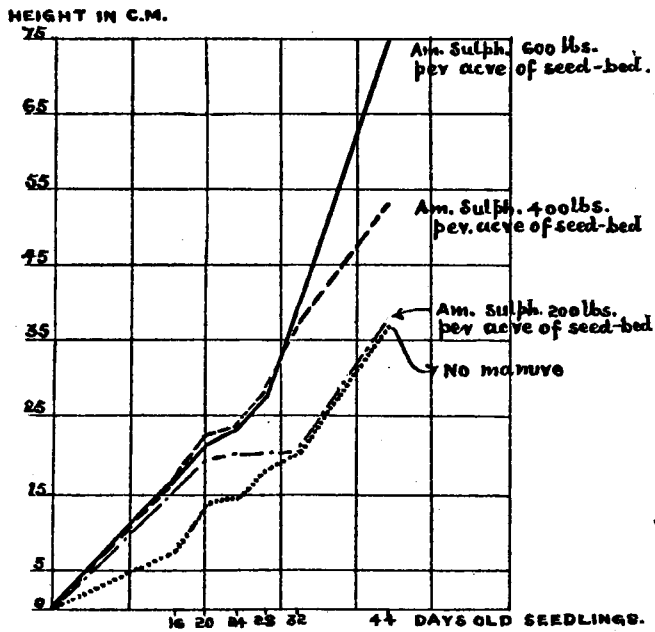
The early growth of the seedlings with regard to their *height* is not very much affected by the seed rate or by the space allotted to each plant, but the capacity to produce tillers is largely influenced by the seed rate, that is to say, by the space allotted to each plant.

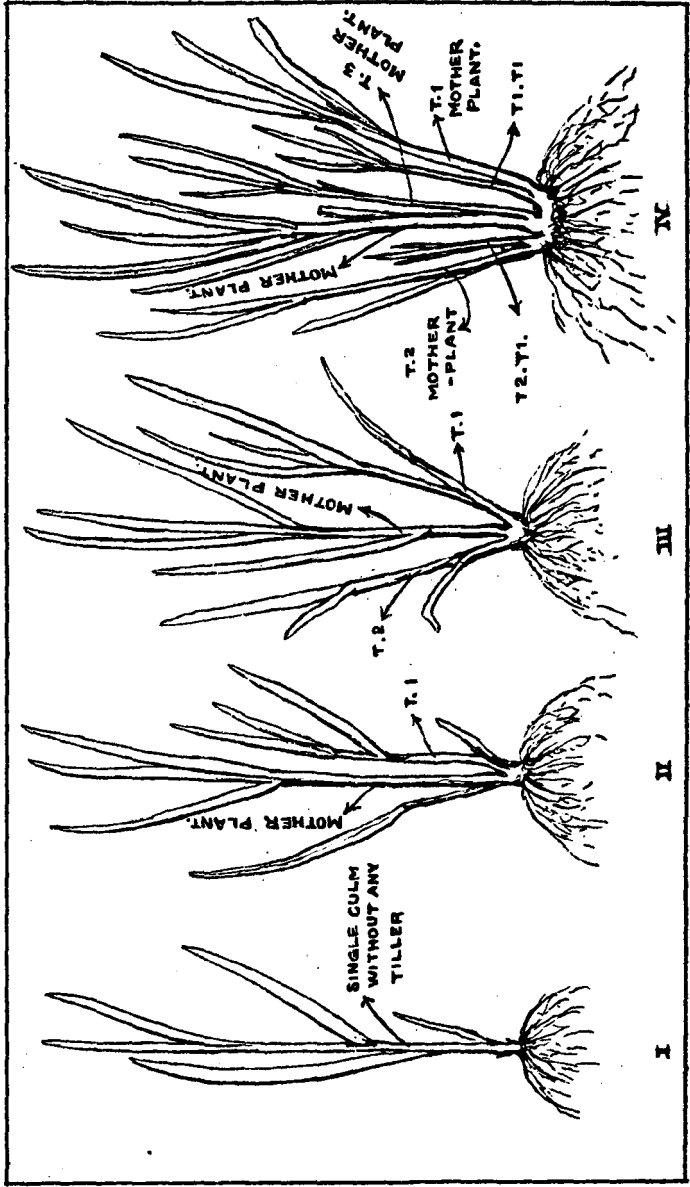
The effect of varying seed rates on the height of the plant is seen from the following table. The figures are obtained by averaging the measurements of five plants in each plot kept under observation :—

Seed rate per guntha. (Seed-bed with <i>rab</i> ).	Height of the plants in centimetres.						
	After 15 days.	After 20 days.	After 25 days.	After 30 days.	After 35 days.	After 40 days.	After 45 days.
1 lb. per guntha* ..	17.1	31.3	41.7	49.5	65.7	84.9	97.6
2 lbs. do. ..	17.8	33.7	42.7	58.1	75.2	87.4	98.0
3 lbs. do. ..	15.1	30.3	39.7	50.2	68.7	82.5	90.6
5 lbs. do. ..	15.1	31.4	44.9	55.7	70.9	83.8	90.4
6 lbs. do. ..	17.1	32.1	48.1	57.9	76.1	83.3	84.4
8 lbs. do. ..	19.1	36.4	56.1	64.5	78.0	86.9	89.0
10 lbs. do. ..	17.1	36.1	50.0	60.6	73.6	79.7	81.1

\* One guntha = One fortieth of an acre.

**GRAPH SHOWING THE RATE  
OF GROWTH IN HEIGHT OF RICE-  
SEEDLINGS, RAISED ON  
AMMONIUM SULPHATE.**





METHOD OF TILLERING IN RICE

It will be observed that the height of the seedlings is nearly equal in all plots till about forty days have elapsed, after which the thin sown crop shows a slight increase in height. This is apparently due to the arrest of growth due to crowding in the thickly sown seed-bed.

*Tillering in the seed-bed.*—If space is available the seedlings begin to tiller in the seedbed. Each leaf has an axillary bud. These buds develop and produce shoots which form the tillers of the plant. Whether or not all the buds develop into tillers depends upon several factors of which space is an important one. In thick sown beds the stand of the crop is so close that there is hardly any room for lateral growth on the part of the plant. On the other hand when the seed is sown thinly the plants begin to grow laterally. Under favourable conditions of plant food and space, the lateral growth commences after *the plant has produced the fifth leaf and not earlier*. The growth of a pinkish white scaly leaf precedes the growth of the green underground shoot which forms the tiller. The scaly leaf, which is small in the young seedling, but which is a very well grown organ in older plants, is folded in its structure and its cross section would be like the English letter M, the side flaps enveloping the shoot, and *the sheath of the mother culm fitting in the central notch*.

The scale-leaf serves the function of a cushion protecting the young tiller shoot. When the tiller emerges from the sheath of the leaf from which it originates, it pushes the leaf down and the latter ultimately falls and rots. The tillers are usually produced on alternate sides of the main shoot. The tiller behaves as a new individual and the vertical and lateral growth both of the mother and the tiller may go on simultaneously. A tiller may, in fact, produce its own tiller and so on, that is to say it leads in every way an independent life.

In practice the seed is not sown so thinly in the seed-bed as to allow very much tillering of the seedlings to take place. But given room and plant food the seedlings produce a larger and larger number of tillers as the following figures indicate :—

Seed rate per *guntha. (Seed bed with <i>rab</i> ).	Days required to produce tillers.					
	1st tiller.	2nd tiller.	3rd tiller.	†4th tiller.	†5th tiller.	†6th tiller.
1 lb. ..	16	19	23	25	† 26	† 27
2 lbs. ...	16	20	23	25	..	..
3 lbs. ...	20	26	..	..	..	..
5 lbs. ...	20	26	..	..	..	..
6 lbs. ...	24	Only 10-15 per cent. of the plants had tillered at all.				
8 lbs. ...	24	do.	do.	do.	do.	do.
10 lbs. ..	No tillering at all.					

It is clear from the foregoing statement that the smaller the seed rate the greater is likely to be the tillering. In the case of heavy seed rates

\* One guntha = One fortieth of an acre.

† It is possible that these were secondary tillers produced from the earlier tillers.

no tillering takes place for want of space. The rate of the lateral growth is also faster in thin sown seedbeds. Thus given sufficient space and plant food the plant would not only produce tillers but do so more rapidly.

It has always been observed that in seed beds, which have not been treated with *rab*, tillering does not take place for a long time in spite of enough space or a low seed rate. Thus space alone without proper condition of the seedbed is not sufficient to give the maximum amount of tillering.

*Leaf Formation.*—The space for each seedling does not affect very markedly either the number of leaves produced or the rate at which they are produced. This is easily seen from the following table.

Seed rate per guntha. (Seed-bed with <i>b.</i> )	Days required for the production of successive leaves.				
	3rd leaf.	4th leaf.	5th leaf.	6th leaf.	7th leaf.
1 lb. ..	14	17	20	24	27
2 lbs. ...	14	17	19	24	27
3 lbs. ...	15	18	21	24	31
5 lbs. ...	14	17	20	24	30
6 lbs. ...	14	18	21	26	29
8 lbs. ...	15	17	20	24	30
10 lbs. ...	14	18	21	25	34

It will be observed that the leaves are formed generally at the same rate whether the seed is sown thick or thin. The production of new leaves, however, is slightly retarded in thick sown beds after five or six leaves have been produced. It may be noted here that the rice plant in the seed bed generally keeps five green leaves. On the appearance of a further new leaf from within, the outermost leaf begins to fade and ultimately drops.

The space in the seed-bed, however, seems to affect the breadth of the new leaf as will be seen from the statement given below. It will be seen from it that the breadth of the new leaf gradually decreases with the increase of seed rate.

Seed rate per guntha. (Seed-bed with <i>rab</i> ).	Breadth of the top leaf at the following ages of the seedlings in m.m.						
	15 days.	20 days.	25 days.	30 days.	35 days.	40 days.	45 days.
1 lb. ..	5½	7	8½	10	12½	14	14½
2 lbs. ...	5	7½	8½	10	12	13	14
3 lbs. ...	4	7	8½	9½	12	12½	13
5 lbs. ...	4	6½	8½	9	10	11	11
6 lbs. ...	4½	5½	8½	8½	10	13	13
10 lbs. ...	3½	6	6	8	9	8½	8½

The treatment of the soil influences the leaf formation considerably as will be seen from the figures given below, of seed beds treated with *rab* and without *rab*.

Treatment of seedbed.	Days required for the appearance of successive leaves.		
	1st leaf.	2nd leaf.	3rd leaf.
Seedbed with <i>rab</i> .. .. .	6	9	13
Seedbed without <i>rab</i> .. .. .	6	13	19

The effect of Sulphate of Ammonia applied as a manure to the seed-bed is similar to that obtained by the *rab* treatment.

Manure (Sulphate of Ammonia) per guntha of seed-bed.	Days required for the appearance of successive leaves.				
	2nd leaf.	3rd leaf.	4th leaf.	5th leaf.	6th leaf.
No manure ..	14	19	24	29	..
5 lbs. } Sulphate of Ammonia. {	..	14	24	30	..
10 lbs. } {	..	Before 14 days.	20	26	..
15 lbs. } {	..	Do.	19	24	29

It is clear from these statements that any treatment which improves the growth also increases the speed of leaf formation.

#### (E). The Growth of the Stem.

*The Leaf Sheath.*—It has been already indicated that the part of the plant popularly known as the stem is formed of the several leaf sheaths overlapping one another. The leaf sheaths in the young stage are very thin and small. But as the plant grows and the plant's capacity to use the available food increases, the sheaths increase in length and thickness. In unmanured seed-beds the structure of the sheath is very hard, while in beds manured with artificial manures like Sulphate of Ammonia, oil cakes, etc., the sheaths become spongy. In the seed-bed treated with *rab* they are less spongy than with the manures mentioned and are stiff. In thick sown seed-beds the sheaths grow well, but are thin.

For the further manipulation which the plant undergoes in transplanting a hard sheath is much better than a succulent spongy one, and hence it is important that the seed-bed should be so treated as not to encourage the tendency towards the formation of spongy sheaths. Sheaths with soft tissue are also undesirable as they are easily bored through by stem borers, even in the seed-beds.

*The True Stem of the Rice Plant.*—The real stem in the rice plant is not visible in the early period of its growth, being covered all round by the sheaths of the leaves. The stem is very low in growth and is so short that it is usually entirely under ground. It grows and appears above the soil surface in a treated seed-bed after a period of five to six weeks after sowing. The leaves are produced from the stem situated under ground. Every leaf leaves a scar on the stem and if a longitudinal section is taken, these scars are seen to be the nodal points of the stem. There are septa inside the stem at the points indicated by these scars and the space between two such septa forms an internode. The successive internodes become longer and longer.

Although in the early parts of its life the rice plant does not utilise its energy in developing the stem to any appreciable extent, and it is the leaf and vegetative production that is usually almost exclusively in progress during this period, still certain adverse conditions may hasten the growth of the stem above ground.

Thus in a thick sown seed-bed the plants grow tall and thin on account of crowding and find difficulty in standing erect. Under these conditions the stem grows above the ground, forms a node and thus supports the plant. In thin sown seed-beds the seedlings are proportionately very thick, and no such node above ground in the stem is found.

In practice, seedlings are generally uprooted for transplanting before the stem has produced a node above the ground in the seed-bed, as seedlings with nodes are considered unsuitable for transplanting in Western India. The causes underlying this belief are discussed in a later chapter.

## CHAPTER III.

### THE TRANSPLANTING OF RICE.

Seedlings are generally uprooted for transplanting when they are grown about eighteen inches high. In the seed-bed treated with *rab* or manure this height is attained in about three weeks from sowing. Transplanting is a very slow and laborious operation, and as a rule it is in progress for over three weeks in any tract. Thus under normal conditions of climate, seedlings are planted at ages varying between twenty-one and forty-two days. The seedlings in the cultivators' seed-beds generally begin to produce nodes above ground after about forty days and the operation of transplanting is just finishing by that time if favourable weather conditions for transplanting prevail.

On transplanting, the plants droop for from four to eight days according as the seedlings are young or old and the sky is cloudy or clear. If there is bright sunshine after transplanting, the crop fades and the leaves roll up probably to reduce transpiration. The best environment is a drizzling misty rain. Young seedlings revive in about four days, while old ones, that is to say seedlings fifty days or more old, take about a week or a little more.





Plants separated from a bunch after harvest, showing unilateral method of rooting.

If plants are pulled up eight to ten days after transplanting most of them show a newly formed first node just below the ground level. The growing point is thus brought near the surface of the soil. Evidence is accumulating to show, however, that the formation of this node is a function of the plant at a definite period of growth and under the usual seed rate of the locality seedlings form the first node at the age of about thirty-five to forty days. This period does not seem to be affected by the process of transplanting as the young seedlings of sixteen to twenty days, on transplanting do not produce this underground node for two to three weeks. Thus, whether a seedling remains in the seed-bed or is transplanted the first node is probably formed between thirty-five to forty days after sowing.

(A). *Root Formation on Transplanting.*

The roots carried by seedlings invariably become unserviceable after transplanting. In a normal case new roots are produced in about forty-eight hours after transplanting from the same old root zone. In fifty-five hours these grow to about a length of one inch and in seventy-two hours they measure  $2\frac{1}{2}$  to 3 inches in length.

As the growing point of the plant comes up to the surface by the formation of nodes new roots are thrown out at each of the new nodes formed underground after transplanting, which may be one or two in number. The topmost node in the ground is the zone for further root formation in which the feeding roots of the plant are found. Under normal conditions the growing point usually reaches the ground surface in about eight to ten days after transplanting. The new roots begin to feed the plant and the crop looks fully revived and changes its colour to dark green in about fifteen days.

From the point of view of root production in bunch planting the whole bunch tends to behave like a single plant and the roots are produced, to by far the greatest extent, on the outer side of the bunch. Very few roots are produced in the interior of the bunch. As the crop grows, new roots are produced by the plants successively from the same rooting zone in an acropetal manner. The roots are fibrous and branched, and they spread obliquely to a depth of six to nine inches or more in the soil, depending on its depth.

When the growth of the roots was studied in open dishes it was observed that on uprooting, new roots begin to appear in about forty-eight hours. In ninety-eight hours they had grown to a length of two inches and in one hundred and twenty hours to a length of three inches. While these are growing other new roots are being produced by the plant from the same node as the original seedling roots. The first new roots are thick, succulent, and milky white in colour, while the later ones diminish in thickness. After growing for five to six days the newly formed roots begin to ramify. The roots then slowly begin to develop a brownish tinge on their surface and become hardened. Gradually the whole surface of the roots except one or two inches at the tip is covered with rootlets.

It has already been stated that the old roots carried by the seedlings before transplanting appear to become unserviceable and the plant has to produce new roots at the same or at a higher node. The unserviceability of the old roots has been twice proved in field experiments. In 1918, two plots in duplicate were planted with seedlings, all the old roots from which had been specially removed by scissors before planting. The vigour and the yield of the resulting crop was equal to that in which the crop was grown with the usual roots.

In 1919 the following results were obtained :—

Treatment of the plot.	Yield per acre. ( <i>Average of duplicates.</i> )	
	Grain lbs.	Straw lbs.
Seedlings planted with usual root system ..	3,385	3,564
Seedlings planted with all their roots specially removed ..	3,448	3,564

The results are clear enough to show that the crop does equally well without the old roots. In fact, it has always been observed that the roots of the seedlings on uprooting die and do not survive. Similar observations have been recorded by Graham in his Preliminary Note on the classification of rice in Central Provinces.\*

#### (B). *Death of Plants on Transplanting.*

In practice from fifteen to twenty per cent. of the seedlings die, on the average, on transplanting, and one of the reasons for planting a larger number of seedlings in each bunch seems to be to provide for such a common contingency. The chief reasons for these deaths so far as the authors' observations go are (1) the injury done to seedlings in uprooting, (2) the use of succulent seedlings grown in thickly sown and overgrown seedbeds, (3) heavy floods and long standing of water in fields soon after transplanting and (4) damage by insects and crabs.

In the process of uprooting seedlings, if the seeds have been sown deep, or if the soil is heavy and the workers are careless the roots and the growing point of some of the seedlings remain in the ground and the seedlings are broken in the process of pulling. Such seedlings of course cannot grow and hence are useless.

In thick and overgrown seedbeds the sheaths are thin and elongated and they become very soft and succulent. Such seedlings on planting in puddle show a great tendency to rot. Some succumb if heavy floods cause water to stand for several days together in the fields soon after transplanting. Under these conditions algæ begin to grow on the sheaths and blades of the seedlings and soon envelop them causing choking up of the plant and ultimately death. Others are damaged by insects chiefly

\*R. J. D. Graham—Preliminary note on the classification of rice in the Central Provinces—Mem. Dept., Agri., India, Bot. Series, Vol. VI, No. 7, pp. 213.

crickets and crabs. In tracts, therefore, where heavy rains and floods are often received during the transplanting season, the number of seedlings to be planted per bunch must be kept high.

The effect of the age of the seedlings on transplanting in the likelihood of death occurring, is shown in the following statement based on results obtained in two successive years. The figures show that old and nodded seedlings are undesirable.

Age of the seedling at planting.	Percentage of bunches in which death of some of the planted seedlings occurred.			
	1920 I	1920 II	1921 I	1921 II
16 days .. .. .	Nil.	Nil.	Not transplanted.	
24 days .. .. .	Nil.	Nil.	Not transplanted.	
32 days .. .. .	Nil.	Nil.	Not transplanted.	
40 days .. .. .	24	34	37	65
48 days .. .. .	38	14	62	65
56 days .. .. .	51	45	64	54
64 days .. .. .	7	66	41	62

Vigour, as determined by thickness of seedlings, keeps down the death rate very much as will be seen from the results shown in the following statement. In the same seedbed all grades of seedling in thickness are obtained due to uneven seeding, and hence a certain percentage of very thin seedlings is always obtained. These are very liable to rot.

Seedlings used in planting.	Percentage of bunches in which some seedlings rotted.		
	1920 I	1920 II	1921
1 to 2½ m.m. in thickness ..	20	38	100
4 to 5½ do. do. ..	10	7	Not planted.
6 to 7½ do. do. ..	3	11	25

It will be seen from the statement that the thicker the seedlings the less are they liable to die on planting. The higher percentage in 1921 is explained by the fact that the seedlings were older than in 1920.

The percentage of death on transplanting caused by bad pulling would be still higher had it not been for certain characteristics of the rice plant which enable it to overcome such injuries. In fact, if a seedling is damaged only in the sheath and its growing point is not injured, it can still survive. Under such circumstances the dormant axillary buds sprout and produce shoots. Old seedlings which have formed one or two nodes in the seedbed, if injured in uprooting, would produce new shoots from the nodes. It is a point of great interest that the rice plant has a capacity to produce a shoot from each node like the sugarcane plant. If

a noded seedling is placed flat on wet soil it will produce shoots from each of the several nodes.\* Even if the seedlings are cut into as many sets as there are nodes and the sets are planted like sugarcane, they will produce shoots. Of course care has to be taken to see that they are not planted submerged under water.

This character of the rice plant was studied in connection with the investigations of the effect of transplanting old seedlings which had formed nodes above ground. For this purpose one hundred noded seedlings were taken and each was cut into two portions, the lower one carrying the roots and the first internode and the other consisting of the remaining portion of the seedlings. These were separately planted in small plots. In the plot planted with the lower set ninety-six of them produced shoots from the dormant axillary buds and developed them into normal plants. In the other plot in which the upper portions without the roots were planted, eighty-six of them survived and developed into a crop. This shows that damaged rice seedlings can develop into a crop by shooting from the dormant buds, and this fact reduces the chance of a further death rate of seedlings on planting.

(C) *Principle underlying the System of Transplanting.*

In the rice growing countries of the world three methods of cultivation are in vogue, namely (a) broadcast sowing of dry or sprouted seed *in situ*, (2) drilling and (3) transplanting. But by far the most common of these is the method of transplanting. It has been the belief among rice growers and others that beyond its undoubted advantage in assisting to keep up the purity of the variety it makes the plants more productive. Graham in his preliminary note on the classification of rice in the Central Provinces (India) (*Memoirs, Department of Agriculture in India, Botanical Series, Vol. VI, No. 7, pp. 213*) says " . . . . Transplanting acts in a way like root pruning, the injury to the root system stimulating the growth of the subærial portion and resulting in increased tillering."

H. W. Jack in his "Preliminary report on experiments with wet rice in Krian (*Agricultural Bulletin, Federated Malay States, Vol. VII. No. 5, 1919*) says " . . . . the end results as far as tillering and yield are concerned is the product of the resultant of two factors, *viz.*, a stimulus due to shock of transplantation and a nutrition factor dependent on the richness of the soil in plant food."

The present authors had also the same notion about the effect of transplanting, but their recent studies of the growth of the rice plant and its response to its environment have resulted in changing their views on this matter. The reasons which are responsible for this change may now be discussed.

*Stimulus due to Root Pruning in Transplanting.*—Writers have always claimed that the root pruning that takes place in uprooting seedlings for transplanting gives a great stimulus to the plant which results in increased tillering and so in greater yield. Evidence is now

\*S. N. Sil.—"Paddy Experiments at Sabour"—Pamphlet, Dept. Agri., Bihar and Orissa, India.

accumulating to show that this belief is not correct, and the authors may refer to several experiments in this connection.

In two plots grown respectively by square sowing and transplanting, the average number of tillers, and ear heads produced per bunch planted or sown with six plants per bunch were determined with the following results.

Treatment.	1921.	
	Average tillers per bunch.	Average earheads per bunch.
Square sown, 6 seedlings 12 inches apart	12.3	11
Transplanted do.	10.7	9.7

The figures given are the average of two experiments and they indicate that though the square sown plot had not got the stimulus of the interference with the roots by uprooting, yet it has tillered as well as the transplanted crop.

That the injury done to the roots during the process of transplanting does not necessarily give any stimulus to the growth of the crop is also suggested by the fact that little influence on the further development of the plants is produced by actually pruning the roots of the seedlings at transplanting. The following are the records of an experiment conducted in 1919 where in one case the whole of the roots were carefully retained at transplanting, in another all were actually removed. Another similar experiment is recorded on page 19.

Treatment.	Yield per acre.	
	Grain lbs.	Straw lbs.
Seedlings with full roots transplanted ..	3582	3894
Seedlings with all roots re- moved by scissors and transplanted ..	3633	3960

There is certainly an increased yield as the result of root pruning, but it is within the error of experiment.

In the *byasi* cultivation followed in the Central Provinces and Orissa where seed is sown broadcast *in situ*, it has been believed that the higher yield obtained by ploughing through the crop when it is about a month old is the result of injury done to the roots. But this does not seem to be necessarily the case for tillering in rice is chiefly a matter of more space and plant food as will be seen in a later chapter. The higher yield obtained in the *byasi* system may rather be due to one or the other or both of the following causes. Either the ploughing loosens the soil and

\* G. C. Sherrard.—A summary of the experiments on rice in Bihar and Orissa from 1912 to 1919—Bull. No. 96, Agri. Res. Institute, Pusa, India,

thus makes increased root formation and growth more easy, or it thins out the crop and thus gives room for the plants to tiller.

The actual experiments on which the conclusions as to the beneficial effect of the treatment in question are based is as follows \* :—

Seed rate per acre.	Treatment after sowing.	1917-19	
		Yield per acre.	
		Grain lbs.	Straw lbs.
70	Ploughed through the crop ..	1,850	4,047
70	Not ploughed through ..	1,455	4,405

The effect of ploughing through seems to reduce the straw and increase the grain. The ploughing through checks the growth for a period of about twelve to eighteen days, allows the crop to tiller and thus to produce more grain and less straw. The unploughed crop grows tall due to crowding, but produces a proportionately smaller earhead.

From all that has been said above, it will be seen that there is little evidence that the operation of uprooting and transplanting brings about any physiological change in the plants so as to make it more productive. In fact it seems to be only an expedient to suit the climate and soil conditions as will be shown later.

*Transplanting versus Square Sowing.*—That equally good yields can be obtained by methods other than transplanting can also be illustrated by the following :—

A method of growing rice by dibbling the seed in squares direct in the field where it is finally to be grown (so called "Square Sowing") has recently been experimented with by Mr. P. G. Joshi at various centres in Western India on low-lying and ordinary rice land, and the authors are permitted to reproduce the figures of average yield which he has obtained in a number of years. They are as follows :—

*Bassein Gardens, 1913.*

1. *Medium Rice Land*—
  - Square sowing .. .. . 1,787 pounds grain per acre.
  - Transplanting .. .. . 1,938 pounds grain per acre.
2. *Low-lying Rice Land*—
  - Square Sowing .. .. . 1,957 pounds grain per acre.
  - Transplanting .. .. . 1,932 pounds grain per acre.

*Alibag Farm, 1913.*

1. *Medium Rice Land*—
  - Square Sowing .. .. . 2,482 pounds grain per acre.
  - Transplanting .. .. . 2,333 pounds grain per acre.

\* G. C. Sherrard.—"A summary of the experiments on rice in Bihar and Orissa from 1912 to 1919"—Bull. No. 96, Agri. Res. Institute, Pusa, India.

2. *Low-lying Rice Land—*

Square Sowing	..	..	1,669 pounds grain per acre.
Transplanting	..	..	1,758 pounds grain per acre.

*Tadvagle, 1913.*

Square Sowing	..	..	2,647 pounds grain per acre.
Transplanting	..	..	2,433 pounds grain per acre.

*Bassein Gardens, 1914.*

Square Sowing	..	..	2,820 pounds grain per acre.
Transplanting	..	..	2,612 pounds grain per acre.

Taking all these results together, they indicate, that if a good system of direct sowing is adopted, as good yields are obtained as by the more normal method of transplanting. The average yield in the one case (square sowing) is 2,064 pounds of grain per acre and in the other (transplanting) is 2,075 pounds of grain per acre. They suggest at least that if direct sowing usually gives a materially smaller yield than transplanting this is rather due to unfavourable environment than to anything essentially inferior in it.

Similar experiments of growing rice by square sowing were also conducted for two years at the Karjat Rice Research Station, the results of which are detailed below :—

Treatment.	Yield per acre.			
	1920		1921	
	Grain.	Straw.	Grain.	Straw.
	Pounds.	Pounds.	Pounds.	Pounds.
Square sowing at 12 inches apart with 6 seeds per hill and interculturing ..	3,871	3,650	2,215	2,293
Transplanting 6 seedlings at 12 inches apart ..	3,620*	4,200	1,922	1,977†
Transplanting do. ..	....	....	2,460†	2,489

Crops grown by this system, however, would require more attention to the control of water in the early growth of the crop, to the filling of gaps, and to weeding so as to secure freedom from weeds. But as these operations are spread over a longer period in the season a cultivator would probably be able to grow a larger acreage than by transplanting, which entails very heavy labour during a very short period.

\* Not planted equidistant.

† This is another plot in a lower series where the soil is even and good. The soil of the transplanted plot is a bit shallower and hence, the results of another plot transplanted similarly in a lower series are given in addition



Evidence again has also been forthcoming to support the view just expressed from other rice growing countries. Summers\* expresses his opinion as follows :—“ It has been shown, however, in the case of the pure lines worked upon, that when paddy seeds are sown at such intervals as to give the plants the same amount of space for development as seedlings which are transplanted into the same field where naturally all soil factors are equivalent, the transplanted plants are very inferior both as to tillering capacity or individual yield to these former. Obviously then the shock factor cannot be alone responsible for increase of tillering, and other factors must be called in to explain it. It also indicates that successfully drilled paddy, in addition to eliminating the costly and laborious process of transplanting must furnish greater yields than either broadcasted or transplanted, and at the same time effect a great saving of seed paddy.”

The evidence quoted so far clearly indicates that rice can be cultivated as successfully without transplanting.

(D) *Conditions determining the method of growing rice.*

Rice is a semi-aquatic plant and it needs much larger quantities of water for its successful cultivation than almost any of the other cereals. Like all other crops, however, it has been grown within certain ranges of soil moisture and rainfall with proportionately reduced yields. Apart entirely from the definite use of stored water for irrigation, this range varies from 30 to 150 inches or even more of rainfall during the growing season. In tracts where (either on account of heavy rainfall or water saturation in the soil with smaller quantities of rain brought about by the peculiar soil and subsoil conditions), other crops cannot be successfully grown, rice is the crop selected for cultivation.

In connection with the question of what system of cultivation should be adopted for rice in a given tract it is well to remember that although a semi-aquatic plant rice cannot withstand much water standing in the field in its early days. If made to grow under such conditions it succumbs. In tracts, therefore, where the monsoon opens with heavy rains causing flooding of the field, the water of which cannot be quickly drained away, the crop would be likely to rot if sown *in situ*. But where the early rains are light and the total rainy season long enough, with fairly heavy showers in the period after six to eight weeks after sowing to enable the cultivator to impound water in the fields after the crop has made some advance, rice can be as well grown by either drilling or broadcasting. In some tracts this water required for impounding may come from a tank instead of from the rains.

Such conditions actually prevail in the Bombay-Karnatak, and in parts of North Kanara, where rice is successfully grown by drill sowing. In the small state of Travancore†, the southern-most part of India, rice is cultivated either by broadcasting or transplanting depending on the nature and the quantity of rain. In parts of Madras where two rice

\* F. Summers.—“The Tillering of Ceylon Rices”—*The Tropical Agriculturist*, Vol. LVI, No. 2 (1921.)

† N. Kunjan Pillai—Rice cultivation in Travancore. *Agri. Journal*, India, Vol. VII, Part II.

crops are grown, the first which is generally an early variety is sown by the system of broadcast sowing, as the southwest monsoon is not heavy there. But the second crop, which is cultivated in the northeast monsoon, which is heavy and the water of which is also supplemented by tank irrigation, is grown by transplanting. In the Central Provinces and in Orissa transplanting is very rarely resorted to, most of the crop being grown by the *byasi* method, a form of broadcast sowing. Here the duration of the rainy season and the quantity of rainfall is comparatively small. In Italy and America where rice is grown under irrigation it is drilled and not transplanted.

In tracts of heavy rainfall, the crop can be easily saved from the ill effects of standing water in the early days of growth by raising it in a high-situated or well-drained seedbed and then transplanting the seedlings when grown sufficiently tall. The grown up seedlings can withstand, nay flourish under swampy conditions as the crop then gets the optimum water supply. Even in the very heavy rainfall tracts if by special arrangements the inflow of excess water can be avoided in the fields in the early days of the crop and if the accumulated rain-water can be easily drained away rice can be grown by sowing dry or sprouted seed *in situ* and interculturing both ways, as successfully as by transplanting. This shows that transplanting can be done away with if certain soil and drainage conditions can be maintained. If, therefore, better yields have been obtained by transplanting, the local soil and climatic conditions must probably have been such as have been above described as unfavourable to sowing *in situ* and no sufficient attention given to remove them. The higher yields are also possibly due to the optimum water supply being more certainly obtained in land puddled for a preparation for transplanting.

It is thus the local soil and climatic conditions that would determine which system of rice growing is best. As stated above transplanting is more a measure of expediency than a requisite condition of growing first class crops of rice. Transplanting is, however, economically advantageous for the following reasons :—

(1) It enables the cultivator to give a thorough cultivation to the fields in an economic way.

(2) As the fields are thoroughly puddled all the weeds are destroyed during this operation. Very few weeds appear afterwards under the wet condition of the field.

(3) The seedlings on transplanting in the puddled field can extend their root system very easily in the soft mud where a large supply of untapped plant food is available.

(4) It enables the grower to overcome the heavy rainfall conditions in the early period of the growth.

By far the most important of these advantages is the clean cultivation that is possible. It has been the experience in many parts that the cost of keeping down weeds in other systems of rice cultivation is relatively very great.

## CHAPTER IV.

## THE TILLERING OF THE RICE PLANT.

On reviving after transplanting, the plant begins to produce new leaves and cast off the old ones as the new emerge. After making some progress in this direction the axillary buds begin to develop and grow into shoots, if the favourable conditions which are described below prevail. Under normal conditions this lateral branching is in progress for about three weeks, but under certain conditions such as extra space it may continue till the crop flowers. The lateral branches or tillers as they lead an independent life may also themselves simultaneously produce tillers if favourable conditions are obtained. Thus given full latitude, a rice plant would produce a large clump or a colony of stalks which are related to each other by a fairly long genealogy.

In transplanting, if the growing point is buried in the puddle the tillers would generally come up from the node immediately below the growing point when the latter reaches the level of the soil. In some cases, however, tillers are produced from the successive nodes as is seen from Plate No. 4. But if by using old and noded seedling it happens to remain above ground the plant produces tillers like the roots from the topmost node as well as from those below. This gives the combined plant the appearance of a fan and its handle. Such a condition naturally weakens the plant in resisting the vicissitudes of the weather.

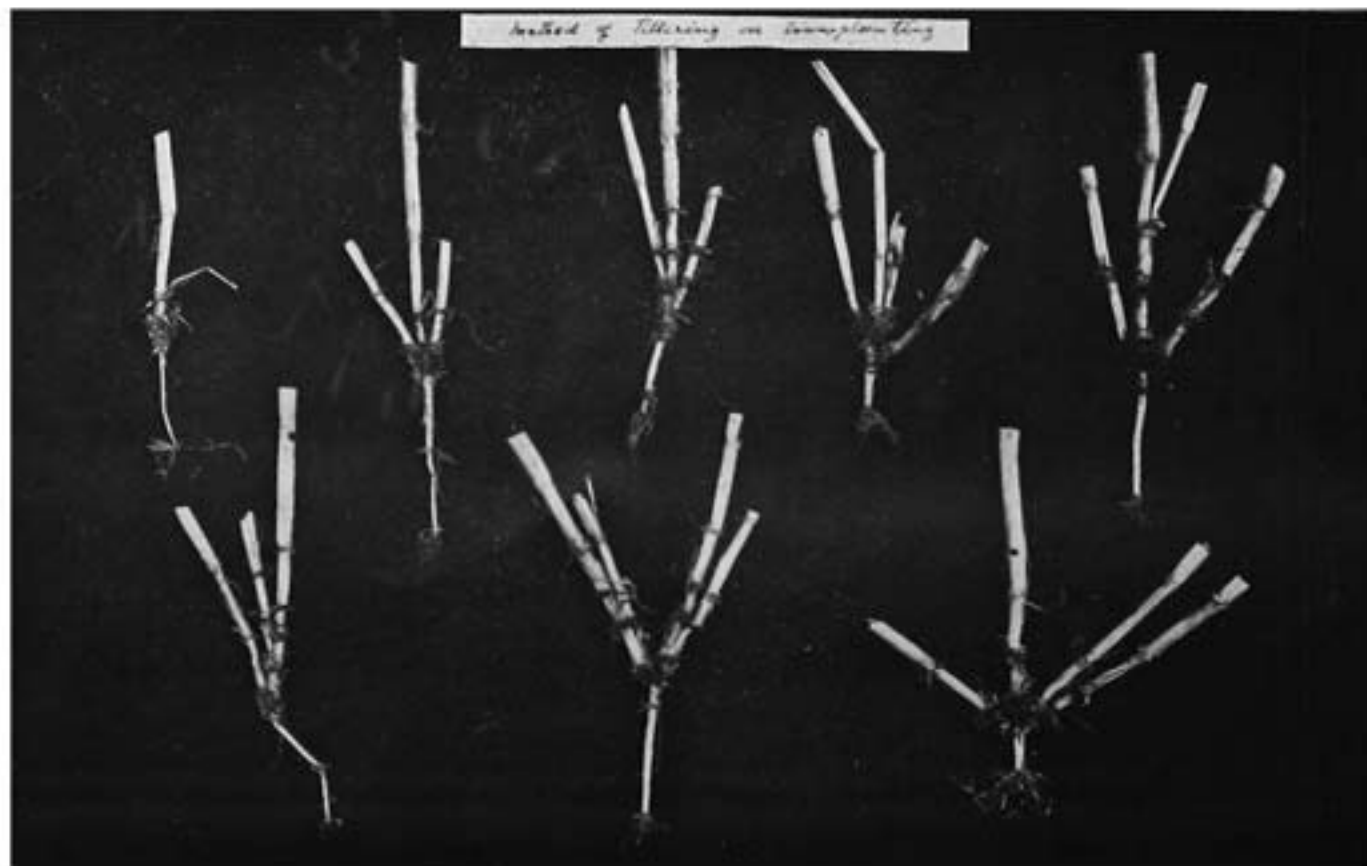
Noded seedlings on transplanting do not necessarily grow erect, but in many cases they take a bend and the above ground node roots and also forms tillers at the node. If there is more than one node to the seedling, it would tiller both at the topmost node and sometimes also at the other nodes touching the ground in the process of taking the knee bend. One such seedling would form as many independent plants as there are shooting nodes.

(A) *Period of Tillering.*

Tillering generally commences fifteen to twenty days after transplanting, and is in progress for about two to three weeks under normal conditions. Summers\* has similarly found that in the case of Ceylon Rice tillering generally commences shortly after transplantation when the plant is about five weeks old and continues up to a period of eight weeks from the time of transplanting. On transplanting the plants generally tiller no matter at what age they are transplanted provided they are not crowded and there is enough plant food. The period of tillering, however, is lengthened or shortened according to the treatment given to the crops as shown below. It is also regulated by the variety and the nature of the climate. The following are the results of definite experiments on this point.

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\* F. Summers—"The Tillering of Ceylon Rices"—*The Tropical Agriculturist*, Feb. 1921



Method of tillering in rice after transplanting.  
Tillers emerge generally from the same node on either sides. But in some cases they are produced from different nodes.



Rooting, shooting and tillering of noded seedlings on planting.  
Note the band that noded plants take on transplanting.

*A.—Effect of Vigour of Seedling.*

Seedlings 39 days old, transplanted July 12, 1921.

	Vigorous seedling.	Poor seedling
1. Time to start tillering after transplanting ..	18 days	18 days.
2. Length of tillering period ..	10 days	24 days.

*B.—Effect of number of seedlings per Bunch.*

Seedlings 40 days old, transplanted July 13, 1921.

	Few seedlings per bunch.	Many seedlings per bunch.
1. Time to start tillering after transplanting ..	18 days	18 days.
2. Length of tillering period ..	12 days	12 days.

*C.—Effect of close and wide planting of Bunches in the Field.*

Seedlings 34-35 days old, transplanted July 8, 9, 1921.

	Close planting, (6 inches apart).	Wide planting, (24 inches apart).
1. Time to start tillering after transplanting ..	18 days	18 days.
2. Length of tillering period ..	17 days	53 days.

*D.—Effect of Transplanting Early or Late in the Season.*

Seedlings 35 days old, transplanted July 9 and August 9, 1921.

	Early transplanting, (July 9th).	Late transplanting, (August 9th).
1. Time to start tillering after transplanting ..	18 days	11 days.
2. Length of tillering period ..	20 days	20 days.

*E.—Effect of Manuring.*—The manure used was a mixture of Superphosphate and Sulphate of Ammonia.

Seedlings, 47-48 days old, transplanted July 21, 1921.

	No manure.	Heavy manure.
1. Time to start tillering after transplanting ..	18 days	18 days
2. Length of tillering period ..	26 days*	33 days.

The general result of all these observations is that none of the treatments given lead to earlier commencement of tillering. Only if transplanting is done late in the season, does tillering begin a little earlier. The length of the tillering period, is however, much affected by the treatment.

\* This period is rather long due to planting four seedlings, twelve inches apart—fairly wide—to suit this experiment.

Even in this matter, the number of seedlings planted per bunch has no effect, nor is the length of the tillering period modified by the age at which seedlings are transplanted. Manure applied to the transplanted field led to a lengthening of the tillering period by twenty-seven per cent. But poor seedlings tillered much more slowly than vigorous seedlings, more than double the time being required to get the full number of tillers produced. The most marked effect was, however, produced by wide or close spacing of the bunches in the field. Between bunches at six inches and at twenty-four inches apart, there was a very great difference. The former had completed tillering in seventeen days, the latter took fifty-three days to make all the tillers that were finally produced.

The effect of spacing between bunches is shown by another experiment in more detail, as follows:—

Spacing given per bunch.		Length of tillering period in days.	
6 inches both ways	.. ..	13	
9 do.	.. ..	13	
12 do.	.. ..	20	
15 do.	.. ..	24	
18 do.	.. ..	31	
24 do.	.. ..	45	

It may be presumed that if the space was still further extended, and the distance between the plants made thirty-six inches, the length of the tillering period would still increase, and the production of side branches would go on until the flowering of the crop.

The tillers as they develop into independent stalks grow along with the mother plant, mature and produce earheads. All tillers, however, cannot develop completely and the earheads produced from different tillers vary considerably in size. Some of the tillers, especially the late ones, do not bear ears at all and they ultimately die. The number of tillers which do not produce earheads increases with the increased tillering as will be seen from the following tables.

#### A.—Effect of age of Seedling.

		Tillers per Bunch.		Earbearing culms per bunch.	
		1920	1921	1920	1921
1.	Seedlings 32-35 days old	14.8	10.1	13.2	8.8
2.	Seedlings 64 days old	19.5	12.6	16.9	11.5

#### B.—Effect of Distance of Planting.

(a) Distances 9 inches and 12 inches apart; eight seedlings per bunch.

		Tillers per Bunch.		Earebearing culms per bunch.	
		1920	1921	1920	1921
1.	8 seedlings per bunch 9 inches apart	9.3	8.9	8.4	8.2
2.	8 seedlings per bunch 12 inches apart	14.1	12.0	13.4	11.

(b) Distances 9, 12, 18 and 24 inches apart : six culms planted in each case.

	Tillers per bunch.		Earbearing culms per bunch.	
	1920	1921	1920	1921
1. 9 inches apart .. .. .	9.3	9.4	7.8	8.2
2. 12 inches apart .. .. .	10.8	12.5	10.5	11.4
3. 18 inches apart .. .. .	21.7	20.5	21.5	18.8
4. 24 inches apart .. .. .	23.9	29.2	23.1	24.7

*C.—Effect of Number of Seedlings per bunch.*

(a) Distance, planted 9 inches apart—

	Tillers per bunch.		Earbearing culms per bunch.	
	1920	1921	1920	1921
1. Two seedlings per bunch ..	7.8	5.0	7.3	5.0
2. Four seedlings per bunch ..	8.8	6.3	8.6	6.0
3. Eight seedlings per bunch ..	9.3	8.9	8.4	8.2

(b) Distance, planted 12 inches apart—

	Tillers per bunch.		Earbearing culms per bunch.	
	1920	1921	1920	1921
1. Five seedlings per bunch ..	13.1	9.7	12.3	9.3
2. Eight seedlings per bunch ..	14.1	12.0	13.4	11.3
3. Twelve seedlings per bunch ..	14.8	13.3	14.4	12.8

*D.—Effect of Manure in Seed Bed.*

	Tillers per bunch.		Earbearing culms per bunch.	
	1920	1921	1920	1921
1. Seedlings grown without <i>rab</i> or manure ..	17.0	11.4	15.2	10.7
2. Seedlings grown with manure containing 2 pounds nitrogen per <i>guntha</i> of seedbed ..	18.6	11.1	16.1	10.5

*E.—Effect of Manuring the Transplanted Crop.*

	Tillers per bunch.		Earbearing culms per bunch.	
	1920	1921	1920	1921
1. No manure .. .. .	29.4	12.1	17.3	11.9
2. Manure containing per acre :				
(a). 100 lbs. Nitrogen* and 1,000 lbs. Superphosphate ..	44.8	23.5	27.1	18.9
(b). 80 lbs. Nitrogen and 800 lbs. Superphosphate ..	46.2	26.4	27.2	19.2
(c). 60 lbs. Nitrogen and 600 lbs. Superphosphate ..	47.0	22.3	29.0	16.0
(d). 30 lbs. Nitrogen and 300 lbs. Superphosphate ..	..	19.7	..	13.4

\* Nitrogen in the form of Sulphate of Ammonia.



Taking all these figures together, the proportion of tillers which formed earbearing culms were as follows:—

*A.—Effect of age of Seedlings.*

	1920	1921
1. Seedlings 32—35 days ..	89 per cent.	97 per cent.
2. Seedlings 64 days. ...	87 ..	91 ..

*B.—Effect of Distance of Planting.*

	1920	1921
(a) 8 seedlings per bunch—		
1. seedlings 3/6 inches apart ..	90 per cent.	92 per cent.
2. seedlings 12 inches apart ..	95 ..	94 ..
(b) 6 seedlings per bunch—		
1. seedlings 9 inches apart ..	84 per cent.	87 per cent.
2. seedlings 12 inches apart ..	97 ..	91 ..
3. seedlings 18 inches apart ..	99 ..	92 ..
4. seedlings 24 inches apart ..	97 ..	85 ..

*C.—Effect of Number of Seedlings per bunch.*

	1920	1921
(a) Distance, planted 9 inches apart—		
1. 2 seedlings per bunch ..	94 per cent.	100 per cent.
2. 4 seedlings per bunch ..	98 ..	95 ..
3. 8 seedlings per bunch ..	90 ..	92 ..
(b) Distance, planted 12 inches apart—		
1. 5 seedlings per bunch ..	94 ..	96 ..
2. 8 seedlings per bunch ..	95 ..	94 ..
3. 12 seedlings per bunch ..	97 ..	96 ..

*D.—Effect of Manure in Seed-bed.*

	1920	1921
1. Seedlings without <i>rab</i> or manure	89 per cent.	94 per cent.
2. Seedlings with manure containing 2 lbs. of nitrogen per acre.	87 ..	95 ..

*E.—Effect of Manuring the Transplanted Crop.*

	1920	1921
1. No manure ..	60 per cent.	98 per cent.
2. Manure containing—		
(a) 100 lbs. Nitrogen* and 10,000 lbs. Superphosphate ..	60 ..	80 ..
(b) 80 lbs. ..	800 ..	60 ..
(c) 60 lbs. ..	600 ..	62 ..
(d) 30 lbs. ..	300 ..	68 ..

\* As Sulphate of Ammonia.

The effect of different methods of treatment on the proportion of the tillers which form earbearing culms is in most cases clear. In the case of very old seedlings, the number of tillers failing to form ears is increased slightly. With regard to the effect of distance of planting, wider planting leads to greater success in the formation of ears by tillers but there is little or no effect by further width of planting after the plants are more than twelve inches apart. The number of seedlings planted per bunch seems to have little effect on the number of tillers which are able to form ears, and manure in the seed-bed seems likewise to have little effect. The results of this power of manuring the growing crop after transplanting are not conclusive.

On the whole it is clear from the tables that heavy tillering is generally accompanied with a larger percentage of loss of late tillers and that this occurs whatever the treatment.

Excessive tillering caused by wide planting should not be encouraged for other reasons also. It brings on uneven flowering and ripening of the crop. All stalks do not develop equally well and thus the earheads produced are of varying sizes. For even ripening and also for producing an even crop it is best (so) to plant the crop as to stop the tillering automatically at a definite stage which will leave sufficient time for all stalks to develop well.

The faculty of tillering possessed by the rice plant makes rice cultivation much more economical than it would otherwise be. It enables the farmer to reduce the seed rate as he can produce two or three ear heads from one seed. The significance of tillering or underground branching in rice is from an agricultural point of view the same as that of the above ground branching in some of the dicotyledonous common crops where the plants have the main shoot purposely nipped off to promote branching. The actual amount of such underground branching or tillering in rice is influenced by several factors which may now be studied.

*(B). Effect of the Age of Seedlings at Transplanting on Tillering.*

Tillering is influenced by the age at which seedlings are transplanted as will be seen from the following statement.

Age of the seedlings at planting.	Tillers produced per bunch of 6 plants planted 12 inches apart.		
	Original series.	Duplicate series.	Average.
1920—			
16 days .. ..	14.7	14.6	14.6
24 " .. ..	14.1	14.7	14.4
32 " .. ..	14.8	13.7	14.2
40 " .. ..	16.5	13.4	14.9
48 " .. ..	19.3	19.7	19.5
56 " .. ..	19.2	17.2	18.2
64 " .. ..	19.5	14.6	17.0

Age of the seedling at planting.	Tillers produced per bunch of 6 plants planted 12 inches apart.		
	Original series.	Duplicate series.	Average.
1921—			
35 days ..	9.1	9.4	9.2
40 " ..	10.0	8.8	9.4
48 " ..	10.0	10.0	10.0
52 " ..	18.8	9.9	14.3
56 " ..	12.0	11.8	11.9
60 " ..	12.0	11.4	11.7
64 " ..	12.6	13.0	12.8

In considering these figures note must be taken that on the whole the tillering in 1921 was poorer than in 1920 due to the unfavourable season and that in 1921 transplanting could not be done earlier than with seedlings of 35 days, for want of water for puddling. Hence the days of transplanting differ in that year's series. It will, however, be seen from both the year's figures that the total tillers produced per bunch on an average increase as older seedlings are used for planting up to a certain limit, a feature which is not quite in accordance with the experience of the cultivators.

The reason for the increased tillering in the late planted plots was studied during the year 1921, and it was found that the old seedlings which have generally produced nodes above ground in the seedbed take a kneebend on planting, and in so doing, some of them take root at the intermediate nodes and at times produce shoots from them. These shoots tiller and thus add to the number. Fields transplanted with old noded seedlings present when tillered more the appearance of a broadcast sown crop than of a transplanted crop as shoots are produced in all directions by the several plants bent obliquely. It is generally the plants situated on the periphery of the bunch that bend outside and form shoots from the several nodes. Those placed inside the bunch do not bend, but grow in one direction. In the experiment quoted above only six plants were used per bunch and most of them could spread out, but in the cultivators' practice where a large number of seedlings is used per bunch, it is only those lying on the outskirts of the bunch that spread obliquely and tiller at different nodes. Hence it may be that the experience of the people is that in their practice the old seedlings do not produce a large number of tillers.

It may be noted here that with the increase in number of tillers the size of the ear head is reduced as will be seen in a later chapter (page 41).

*(C). Effect of the Number of Seedlings Planted per Bunch on Tillering.*

The tillering per plant increases, as would be expected, when the number of seedlings planted per bunch is reduced. The plants were carefully transplanted equidistant in the bunch.

Seedlings per bunch.	Average tillers produced per seedling.			
	Original	Duplicate.	Original	Duplicate.
	1920	1920	1921	1921
(Bunches 9 inches apart.)				
2 Seedlings ..	3.9	3.6	2.5	2.0
3 do. ..	2.8	2.2	1.9	1.7
4 do. ..	2.2	1.8	1.5	1.5
5 do. ..	1.9	1.6	1.4	1.4
6 do. ..	1.6	1.4	1.4	1.2
8 do. ..	1.5	1.1	1.1	1.1
12 do. ..	....	1.0	....	1.0
(Bunches 12 inches apart.)				
4 seedlings. ..		3.4		2.2
5 do. ..		2.6		1.9
6 do. ..		2.3		1.6
8 do. ..		1.7		1.5
12 do. ..		1.2		1.1

It is clear from these tables that less the number of seedlings planted per bunch the more is the tillering per plant.

The rate of the increase in tillering is not proportionate, however to the decrease in the number of seedlings planted per bunch as the total number of tillers produced per unit area increases with the increased number of seedlings planted per bunch up to 12 seedlings as is shown below.

Number of seedlings per bunch.	Total number of earbearing culms per unit area.			
	1920		1921	
	Original.	Duplicate.	Original.	Duplicate.
2 seedlings, bunches 9 inches apart ..	125	119	90	77
3 do. do. ..	145	120	103	95
4 do. do. ..	154	118	109	105
5 do. do. ..	160	118	119	122
6 do. do. ..	157	128	136	130
8 do. do. ..	152	145	149	150
12 do. do. ..	....	167	....	197

The increase in the number of earbearing culms per unit area is associated with a decrease in the average yield per ear head as will be shown later (page 41).

(D). *Effect of Space on Tillering.*

Space has a considerable effect on promoting tillering in plants. The wider the planting the more is the tillering per plant as is shown below :—

Space allotted per bunch of six seedlings.	Tillering per bunch.			
	1919	1920		1921
6 inches both ways ..	8.5	5.5	6.2	6.1
9 do. do. ..	10.3	9.3	7.7	9.4
12 do. do. ..	14.7	10.8	14.2	12.5
15 do. do. ..	17.6	16.3	20.4	18.0
18 do. do. ..	20.5	21.7	15.7	20.5
24 do. do. ..	35.4	28.9	..	29.5

The figures distinctly show that space is a great factor in promoting tillering. The tillering, however, is not proportionate to the extra space given as will be seen from the following figures :—

Spacing given per bunch in square inches.	Ratio of space allotted per bunch.	Ratio of number of tillers per bunch (average).
36 .. ..	1	1
81 .. ..	2.5	1.5
144 .. ..	4.0	2.0
255 .. ..	6.25	2.7
324 .. ..	9.0	3.7
576 .. ..	16.0	5.0

The total number of earheads produced per unit area, therefore, naturally tends to decrease with the increased spacing as will be seen from the following table :—

Spacing.	Total earheads produced per acre, average of duplicates.	
	1920	1921
6 inches .. ..	850,300	959,400
9 " .. ..	590,300	630,700
12 " .. ..	493,100	513,200
15 " .. ..	415,600	438,600
18 " .. ..	358,100	361,500
24 " .. ..	326,100	316,900

These figures suggest that within certain limits, the number of ear-bearing culms (*i. e.*, earheads) per unit area varies inversely as the square root of the distance apart of the bunches.

The average yield per earhead on the other hand increases with the increased spacing as will be shown later (page 45).

(E). *Effect of better Tillth of land on Tillering.*

The preparation of the puddled field for transplanting rice in water is a complicated matter and the more work done on the land the more even and smooth is the puddle. The effect of this is shown below :—

Treatment.	Tillers produced per bunch of seedlings, 1921.
One ploughing and planking before transplanting.	10.8
Three do. do. do. ..	10.5
Five do. do. do. ..	9.7
Seven do. do. do. ..	10.9
Nine do. do. do. ..	12.0
Eleven do. do. do. ..	10.5

There is hardly any increase in tillering as the number of ploughings is increased.

(F). *Effect of Climate and Rainfall on Tillering.*

The nature of the climate and rainfall has a great influence on plants in general and it might be expected that tillering would be affected by these factors. There appears to have been no work, however, hitherto carried on this subject, and hence its exact significance is not known. The figures of tillering of the crop planted with the same strain of Kolamba rice in the years 1920 and 1921 may, however, throw some light on this subject. It may be noted that the rainfall of 1921 was extremely poor in the early part of the season. Though it was very favourable after the operation of transplanting, it could not correct the harm already done. The date of transplanting in 1920 was July 15th and in 1921 was July 16th.

Treatment of the plots.	Tillering per bunch.	
	1920	1921
Transplanting 4 culms obtained from .. .. one seed...	10.6	7.4
do. do. do. 2 seeds ..	12.2	8.0
do. do. do. 4 seeds ..	13.9	9.4

The tillering in the season of 1920 was 48 per cent. greater than in 1921. The rainfall figures for these years are given below in inches.

Month.	Rainfall.			Remarks.
	1919	1920	1921	
	Inches.	Inches.	Inches.	
June ..	28.17	18.57	9.94	From June 4th to July 15th the total quantity of rain received was only 13.83 inches in 1921 compared with 46.04 inches in 1920 and 53.24 inches in 1919 for the same period.
July ..	53.4	40.79	49.40	
August ..	50.3	18.19	23.45	
September ..	11.2	11.81	17.54	
October ..	....	1.74	....	
Total ..	142.26	91.10	99.33	

In 1921 the fields could not be ploughed and kept under water sufficiently long before transplanting. It is very difficult to say how exactly this poor rainfall affected the crop.

(G). *Effect of Manuring on the Tillering.*

Tillering is greatly encouraged by manuring as will be seen from the following table :—

Manure applied per acre.	Number of seedlings planted per bunch.	Tillering per bunch.	
		1920	1921
100 lbs. Nitrogen, 200 lbs. Phosphoric acid .. ..	4	44·8	23·5
80 lbs. of Nitrogen, 160 lbs. Phosphoric acid .. ..	4	46·2	26·4
60 lbs. Nitrogen, 120 lbs. Phosphoric acid .. ..	4	47·0	22·3
20 lbs. Nitrogen, 40 lbs. Phosphoric acid.	4	....	16·0
No Manure .. ..	4	29·0	12·1

It is clear that manuring considerably increases the tillering in the crop and is a practical means of increasing the earheads per acre.

(H). *Effect of the Nature of the Soil on Tillering.*

Tillering is affected by the physical nature and the chemical constituents of the soil. Thus in friable and coarse soils it has been observed that the plants tiller freely, while in sticky and heavy soils the tillering is considerably checked and often no tillers are produced by the plant. The tillering seems to be related to the general development of the root system in the soil. In friable soils the roots can be easily spread while in sticky and heavy soils, like the *manat* soils of the Konkan, the roots are not well developed as they cannot penetrate the fine clay.

The drainage of the soil also influences tillering considerably. When the water drains through the soil, it passes over the root system which is benefitted by the oxygen contained in the water\*. As fresh water is embanked in the field to replace that drained away, the supply of oxygen is kept up and thus the roots develop well and feed the plant better which in its turn utilise the plant food in forming new tillers.

Depth of soil in the field also determines the tillering capacity. In shallow soils the plants do not tiller due to insufficient plant food. With the increase in the depth of soil the tillering increases as will be seen from a series of pot experiments conducted in 1919 and 1921.

\* W. H. Harrison and P. A. Subramania Ayyar—"Gases of Swamp Rice Soils"—Mem. Dept. Agri. India, Chem. Series, Vol. III, No. 3.

Treatment.	Calms planted.	Total tillers produced.
No soil, all <i>murum</i> *	6	6
3 inches soil and all <i>murum</i> below..	6	8
9 inches soil and all <i>murum</i> below..	6	17
15 inches soil and all <i>murum</i> below..	6	18
21 inches soil and all <i>murum</i> below..	6	16
Normal pot with three layers as in the field .. ..	6	12

The effect of depth of soil beyond twenty-one inches has not been tried. As all the pots had a layer of *murum* underneath, the drainage question did not arise in this case.

#### (I). Effect of the Chemical Constituents of the Soil.

The tillering and the vegetative growth is always profuse in soil containing high quantities of organic plant food. Thus in fields situated near villages which annually receive large quantities of organic material in one form or the other, the crop tillers highly and produces vegetative growth to such an extent that it runs to leaf. Such a crop often needs cutting off once, twice or thrice during its growth, to prevent it from producing abortive panicles. The rate of tillering and vegetative growth in such fields is so rapid that it can yield a good crop in spite of other disadvantages such as late planting, etc. In fact in many cases to check the excessive leafy growth in such fields the crop is transplanted twice, once in July wide apart, and again by the middle of August much closer. After the first transplanting, the crop tillers profusely for about a month and the resulting stalks suffice for replanting five to six times its area. After this period, the tillered crop is uprooted and transplanted in August. It re-establishes itself and begins to tiller as the space permits, and in the following six weeks, all the tillers are fully developed and the crop puts forth excellent earheads. A similar practice seems to be in vogue also in the Federated Malay States.†

In such fields if the crop is planted out at the usual distance, it results in running to leaf, as apparently owing to the presence of excess of nitrogenous matter in the soil the crop soon tillers as much as the space allows. When the crop in this manner becomes thick no more tillering is possible and as there is available plant food the plant absorbs it and grows in one direction, namely, in height. A fight for light ensues and the crop grows excessively tall and soft in its tissues, the result being a large attack of stem borer and panicles with a large number of abortive flowers.

\* *Murum* is the porous subsoil generally found in the trap soils of Western India.

† H. W. Jack—"Preliminary report on experiments with wet rice in Krian." Agri. Bull., F. M. States, Vol. VII, No. 5 of 1919.



Excess of potash and phosphoric acid in the soil does not seem to encourage tillering to any extent as will be seen from the statement given below:—

## A.

Treatment per acre.	Average culms produced per bunch.
80 lbs. of phosphoric acid in the form of Superphosphate .. .. .	10.1
40 lbs. of nitrogen in the form of Sulphate of Ammonia .. .. .	14.0
No manure .. .. .	10.9

## B.

Treatment.	Culms planted.	Total culms produced.
Potassium Sulphate 56 lbs. per acre ..	6	12.3
Superphosphate containing 80 lbs. Phosphoric acid per acre .. .. .	6	12.6
Sulphate of Ammonia 40 lbs. nitrogen per acre .. .. .	6	24.0
No Manure .. .. .	6	12.5

Phosphoric acid in combination with nitrogen seems to be more effective although when applied alone it does not show much advantage for tillering. The nitrogen was always supplied as Sulphate of Ammonia.

Treatment per acre.	Average culms produced per bunch.	
	1920	1921
40 lbs. nitrogen 200 lbs. Superphosphate..	18.5	15.2
40 do. 400 lbs. do. ..	17.8	14.0
No manure .. .. .	13.9	10.3
40 lbs. nitrogen 600 lbs. do. ..	20.4	16.0
40 lbs. Nitrogen 800 lbs. Superphosphate..	19.0	16.2
40 do. 1,000 lbs. do. ..	22.8	19.8

The soil fertility and its physical nature thus seem to control tillering to a great extent, and this would seem to have a great significance in the economy of rice cultivation. If a field on account of its fertility and other physical characters of the soil is very suitable for tillering, the crop can be transplanted fairly wide, with fewer seedlings per bunch. But if the field is poor in fertility and has sticky and badly drained soil, the crop cannot tiller freely and the cultivator has to plant close, and has to use more seedlings per bunch. Thus in the latter case, more seed and more area under seedbed would be needed.

The nature of the soil as regards its physical properties and chemical constituents seems thus to determine the seedbed area, required per acre. The area under seedbed per acre differs very much in different localities as will be seen from the figures given below, and the chief reason for this seems to be the varying capacities of those soils to promote tillering of the crop.

Place.	Area of seedbed required for planting one acre.	Nature of soil in the locality.
Alibag	6 to 7 gunthas	Brown clay with a liberal admixture of grit and small stones.
Ratnagiri	10 to 13 gunthas	Laterite poor soils.
Kumta	7 to 10 gunthas	Sandy poor soil.
Karjat	2 to 4 gunthas	Sandy loam.
Lonavala	6 to 8 gunthas	Coarse, red, poor soil.
Coimbatore	2 to 3 gunthas	Gneiss soils, black, fairly fertile with good drainage.
Japan	2 to 3 gunthas	Shallow, coarse and poor soils made fertile by long heavy manuring.
Spain	2 to 3 gunthas	Clay soil heavily manured.

(J). *Effect of Insect Attacks and Abnormalities of Weather.*

If a rice plant is affected by a stem borer at the flowering time it produces a tiller or tillers from the first node above ground as a result of the attack. These late tillers produce panicles when the general crop is ready for harvest and hence they are of little consequence. This is quite similar to the behaviour of other crops like *Jowar* which also produce shoots from the node below the point of injury.

Climatic conditions also seem to cause the production of late tillers from a fresh node as has been observed by Summers in Ceylon.\* He says "If, however, when nearing maturity the plants receive an excess of water, either artificially or in consequence of precipitation two or three smaller tillers may be produced in a fresh tillering phase actuated by the abnormal conditions. These late tillers produce ears which do not normally reach maturity. They have a separate ripening period of their own, the full course of which they are not permitted to pursue".

(K). *Varietal Variation.*

Tillering has been found to vary in different varieties and even in different strains of one variety, as will be evident from the following quoted from the records at Karjat.†

\* *Tropical Agriculturist*, Feb. 1921, page 82.

† These figures have been supplied by Mr. R. K. Bhide, Plant Breeding Expert to Government, Bombay, and the authors are greatly indebted to him.

Variety Kolamba. Strain No.	Number of tillers per plant planted 18" x 9" apart.
110	4.4
79	5.0
35	7.7
6	8.7
32	9.7
42	9.9
3	10.2
134	11.4
113	12.6
104	14.1

It is clear that different varieties produce different number of tillers, the variation in the above table being from 4 to 14 tillers per plant grown under equal conditions of soil and space.

Similar results have also been recorded by Summers\* in Ceylon and Thompstone in Burma.†

#### CHAPTER V.

#### THE DEVELOPMENT OF THE TRANSPLANTED CROP.

##### (A). Growth of the Stem.

Under normal conditions the stem does not grow much till the tillering of the crop is over. The plant then begins to develop the stem in all the stalks. As in the case of all grasses the stem of the rice plant grows rapidly as the flowering time approaches. This rapidity of growth of the stem is very markedly noticed in crops planted very wide apart where the tillering is in progress for a long period.

The internodes formed by the stem increase in length from the bottom to the top. This has been determined by a careful study of 170 stalks from twenty-five bunches picked up from five different plots in a series of experiments as to the best number of seedlings planted per bunch. The result of the study of the lengths of the internodes is given in the following table, the internodes being numbered downwards from the base of the ear.

##### Lengths of Internodes 1921 Crop.

Number of culms examined.	Treatment.	Measurements in length of internodes in cm.				
		V Internode.	IV Internode.	III Internode.	II Internode.	I Internode.
		cm.	cm.	cm.	cm.	cm.
22	2 culms, bunches 9 inches apart	5 to 6	8 to 9	16 to 18	23 to 26	36 to 39
34	3 Do.	6 to 8	9 to 11	18 to 19	27 to 28	39 to 40
38	4 Do.	7 to 8	9 to 11	18 to 19	26 to 28	39 to 40
40	5 Do.	6 to 8	10 to 11	17 to 20	25 to 26	34 to 36
36	6 Do.	6 to 8	9 to 10	15 to 17	24 to 26	34 to 35

\* Summers in *Tropical Agriculturist* (Ceylon) for February 1921.

† Thompstone—Some observations on the Upper Burma paddy grown under irrigation. (*Agricultural Journal of India*, Vol. X, 1915, p. 72.)

From these figures it will be seen that :—

- (1) The lengths of internodes increase towards the top.
- (2) Amongst themselves the higher internode shows an increase of about 40 to 50 per cent. over the one immediately below except in the case of the third where the length is twice as great as that of the second.

*(B). Relation of the Girth of the Lowermost Internode to the Length of the Panicle.*

As a result of the study of over 2,000 stems, it has been found that the girth of the lowermost internode is about one-tenth the length of the panicle in the case of the strain of rice used for experiment in 1921. The analysis of the first five hundred stalks examined is shown in the attached correlation table.

*Correlation between the Girth of the Stem and the Length of the Panicle.*

*Girth of the stem at its lowest internode above ground.*

Length of the Panicle.	Mean value.	14 mm	15 mm	16 mm	17 mm	18 mm	19 mm	20 mm	21 mm	22 mm	23 mm	24 mm	25 mm	Total.
14.5 cm.		2	4	3	..	2	..	..	..	..	..	..	..	11
15.5 "		6	7	3	..	2	..	..	..	..	..	..	..	18
16.5 "		4	7	5	3	3	1	..	..	..	..	..	..	23
17.5 "		1	2	4	5	5	..	1	..	1	..	..	..	19
18.5 "		..	4	2	8	6	5	8	1	1	1	..	1	37
19.5 "		..	2	4	11	12	10	8	2	2	1	..	..	52
20.5 "		..	..	1	6	6	11	30	9	10	2	..	2	77
21.5 "		..	..	..	1	2	5	32	19	8	6	7	5	85
22.5 "		..	..	..	..	1	1	26	18	19	13	8	15	101
23.5 "		..	..	..	..	..	1	4	10	9	6	6	21	57
24.5 "		..	..	..	..	..	..	..	..	1	8	2	6	17
25.5 "		..	..	..	..	..	..	..	1	..	1	..	1	3
Total "		13	26	22	31	39	34	109	60	51	38	23	51	500

The coefficient of correlation works out at  $0.781 + .012$  and indicates a very close relationship between the measurements in question.

Thus by looking to the thickness of the lowest internode, an indication of the size of the earhead can be easily obtained. This is interesting and is of practical use in judging the yielding power of a field by superficial examination of the stubble any time after the harvest. Thick stubble indicates, of course, the richness of the field.

*(C). Flowering.*

For all varieties the time required for flowering from sowing is generally definite. This period is lengthened or shortened by the environment only within narrow limits. Too much water or very rainy conditions

postpone the emergence of the panicle up to about a week. The age at which seedlings are planted affects the flowering by a few days as will be seen from the following statement.

Age of seedling at planting.	Date of flowering after transplanting.	
	1920	1921
16 days .. .. .	4th October ..	Could not be planted.
24 " .. .. .	5th " ..	Do.
32 " .. .. .	7th " ..	Do.
35 " .. .. .	.....	5th October
40 " .. .. .	8th October ..	5th "
48 " .. .. .	10th " ..	5th "
52 " .. .. .	.....	6th "
56 " .. .. .	11th October ..	6th "
60 " .. .. .	" " ..	7th "
64 " .. .. .	" " ..	8th "

The distance in transplanting also influences the time for flowering to a certain extent as will be seen from the following statement. The greater the distance between the bunches the later the date of flowering.

Space given in planting.	Date of flowering after transplanting.	
	1920	1921
6 culms : bunches 6" apart ..	5th October ..	4th October
Do. 9" " ..	5th " ..	4th "
Do. 12" " ..	6th " ..	4th "
Do. 15" " ..	6th " ..	5th "
Do. 18" " ..	9th " ..	5th "
Do. 21" " ..	.....	.....
Do. 24" " ..	9th October ..	6th October

Wider spacing which promotes too much tillering tends to extend the period of flowering and so leads to unevenness in ripening.

#### (D). *The Panicle.*

In different varieties and strains barrenness of some of the end flowers is a distinct characteristic. But apart from this natural defect, certain conditions of growth bring on a greater or less proportion of barrenness of the flowers on a panicle. This will be seen from the following statement.

#### A.—*Effect of Manure.*

Manure per acre.	Percentage of the sterile flowers to grain producing flowers.
	1921.
No Manure .. .. .	3.8
50 lbs. Sulphate of Ammonia. 75 lbs. Superphosphate ..	4.4
150 lbs. " do. 225 lbs. do. ..	4.1
300 " do. 450 " do. ..	4.7
400 " do. 600 " do. ..	5.6

*B.—Effect of Distance of Planting.*—Six culms per bunch were planted in each case.

Treatment per acre.	Percentage of the sterile flowers to grain producing flowers.
Bunches planted 6" both ways ..	3.2
" 9" " ..	3.6
" 12" " ..	4.7
" 15" " ..	5.4
" 18" " ..	5.6
" 24" " ..	6.9

These two treatments both of which bring on some increase in sterility are nitrogenous manuring and wider spacing as is clear from the above table. By both these treatments the plant tends to produce large vegetative growth and there is at least a suggestion that increased sterility is associated with increased vegetative production.

Besides the treatment, sterility also depends, as is well known, on the variety or even on the strain, as different types or strains even of the same variety of rice have been found to yield different proportions of sterile flowers to grain. Figures supporting this observation are detailed below\* :—

Kolamba paddy. Strain No.	Proportion of the weight of sterile flowers to grain.
37	0.9
105	1.0
168	1.4
76	2.0
4	2.5
100	3.0
46	4.0
65	5.0
48	6.0
51	7.0

A high or low percentage of sterility has also been observed to depend on the physical condition of the soil. Thus crops on clay soils have a smaller percentage of unfertilised flowers as at Alibag. Soils of friable and coarse nature seem to produce a large percentage, as at Karjat.

Certain insect and fungus diseases, like the stem borer, sucking insects, nematode worms and the sclerotial disease also often come in the way of fertilisation and filling up of grain.†

\* These figures have been supplied by Mr. R. K. Bhide, Plant Breeding Expert to the Government of Bombay, from experiments made at Karjat and the authors are greatly indebted to him.

† E. J. Butler—"Diseases of Rice"—Bull. No. 34, Agri. Res. Institute, Pusa, India.

It is also believed that the sterility is increased in years when rains are received during the flowering period.\*

(E). *Factors affecting the Yield per Earhead.*

One of the factors which determine the final yield per acre of rice grain is the amount which is obtained from each earhead, and this yield is controlled to a very considerable extent by the varying environment. How far the conditions surrounding growth affect this quantity per earhead may now be discussed and the experiments recorded on which the conclusions are based.

*Effect of Age of Seedlings at Transplanting on the Average Yield per Earhead.*

Age of seedlings at planting.	Average yield per head in tolas.		
	1919	1920	1921
16 days	.....	·221	.....
18 "	·265	.....	.....
23 "	·254	.....	.....
34 "	.....	·198	.....
27 "	·247	.....	.....
32 "	.....	·169	.....
35 "	·230	.....	·206
40 "	.....	·181	·222
43 "	·219	.....	.....
48 "	.....	·150	·198
52 "	·189	.....	·187
56 "	.....	·130	·176
60 "	·162	.....	·161
64 "	.....	·123	·158
73 "	·136	.....	.....

It is clear from the statement that as the seedlings for transplanting become older, the average yield per head begins to decrease. The probable cause of this is that in later planting the period is too short to allow all culms to develop to their full height and vigour, and consequently the panicles put forth by the plants are smaller than in the case of early planting where stalks develop fully.

The quantity of the grain as regards its weight, volume for volume, does not seem to be affected by the age at which the seedlings are transplanted. The following experiment illustrates this. The measure used was a drinking glass with an even edge.

Age.	Weight of 5 measures in tolas 1921.
35 days	117·5
40 "	118·5
48 "	117·3
52 "	116·6
56 "	116·75
60 "	117·75
64 "	116·0

\*E. Thompstone and A. M. Sawyer—"Gwabo" disease of paddy. Bull. 16, Dept. Agri, Burma, India.



**Earheads tend to decrease in size as the number of seedlings planted per bunch increases**



*Effect of the number of seedlings planted per bunch on the average yield per earhead.*—The average yield per earhead is considerably affected by planting a large or small number of seedlings per bunch as will be seen from the illustration and also from the following statement :—

Seedlings planted per bunch.	Average yield per earhead in tolas.			
	1920		1921	
	Original.	Duplicate.	Original.	Duplicate.
2 seedlings ; 9 inches apart ..	·225	·206	·243	·271
3 do. do. ..	·217	·212	·211	·247
4 do. do. ..	·207	·232	·195	·236
5 do. do. ..	·198	·212	·186	·200
6 do. do. ..	·179	·202	·176	·197
8 do. do. ..	·163	·139	·142	nil.
12 do. do. ..	·119	..	·122	..
4 do. 12 do. ..	..	·207	..	·194
5 do. " do. ..	..	·202	..	·211
6 do. " do. ..	..	·198	..	·218
8 do. " do. ..	..	·209	..	·209
12 do. " do. ..	..	·184	..	·178

From all these figures it is clear that the average yield per earhead slowly decreases with the increase in the number of seedlings planted per bunch.

The cause of the production of bigger earheads by planting less seedlings per bunch is obviously the increased space each culm gets when a smaller number of plants are put in. In planting a less number per bunch, although more tillering occurs per plant the total number of ear bearing culms that are nourished per unit area, is always less.

Number planted per bunch.	Total number of earheads per unit area.			
	1920		1921	
	Original	Duplicate.	Original.	Duplicate.
2 seedlings ; bunches 9 inches apart	129	125	154	180
3 do. do. do.	119	145	190	203
4 do. do. do.	128	154	210	218
5 do. do. do.	137	160	244	238
6 do. do. do.	146	157	253	267
8 do. do. do.	159	152	299	292
12 do. do. do.	199	.....	394	.....

Number planted per bunch.	Total number of earheads per unit area.	
	1920	1921
4 seedlings; bunches 12 inches apart	330	422
5 do. do.	334	503
6 do. do.	354	630
8 do. do.	364	609
12 do. do.	319	723

It will be seen from these statements that the total number of ear bearing culms per unit area increases with the number planted per bunch showing that the tillering where the smaller number per bunch is planted is not high enough to make up for the larger number obtained by planting a larger number per bunch.

Thus in thicker bunch-planting there is a larger number that has to feed upon the same space and consequently less plant food and less light are available per plant, and hence the smaller panicle. The difference caused by this varying amount of available plant food and light is very clearly demonstrated by the following statement in which the result of study of all panicles in five bunches of each of the several plots is given.

Treatment.	Number of earheads found in 5 bunches.	Average number of flowers per panicle.		
		Mother culm.	1st tiller.	2nd tiller.
2 seedlings; bunches 9 inches apart.	20	345	297	160
3 do. do.	24	266	217	282
4 do. do.	32	262	202	163
5 do. do.	34	228	164	169
6 do. do.	32	202	173	No 2nd tiller produced.
8 do. do.	44	140	78	Do.
12 do. do.	59	137	72	Do.

It will be seen from this statement that in the same space in a plot with twelve seedlings per bunch there were three times the number of panicles when compared with that in which there were two seedlings (59 against 20). This naturally resulted in reducing the available space and plant food per culm in the plot with twelve seedlings per bunch and hence the panicles are small producing only 137 flowers at an average on the mother culms. The average number of flowers on the mother panicle is 345 in the case of the plot planted with two seedlings per bunch as there were only twenty culms to be nourished in the same area. For this reason, the figures in column 2 are inversely correlated with those in column 3. Studying the outturn of flowers per panicle of the first tiller (column 4) the same decrease is seen as in column 3. The study of this column shows that the panicles of the first tiller in cases of planting of eight and

twelve seedlings per bunch are extremely small. The plants in these had hardly tillered, only two to five per cent. of them putting forth any tillers at all. The percentages of the plants that put forth the first tiller are shown below :—

Treatment.	Percentage of plants that put forth one tiller.	Percentage of plants that put forth two tillers.
2 seedlings ; bunches 9 inches apart	72	9
3 do. do.	61	23
4 do. do.	45	16
5 do. do.	33	8
6 do. do.	10	....
8 do. do.	5	....
12 do. do.	2	....

The second tiller has not appeared at all in plots planted with seedlings above five in number.

The study of the earheads in all these plots revealed the fact that the panicles of the first or second tiller are generally smaller than those of the mother culm, but in very thin planting there is a slight tendency for the tillers to produce panicles bigger than the mother. This occurred in from fifteen to twenty cases out of 245 earheads examined. The probable reason is that the first tiller gets as much space and period to grow as the mother culm in thin planting and hence it puts forth as good or in some cases even a slightly bigger panicle. In thick planting, from four seedlings per bunch and onwards, the panicles on the mother culm are always bigger than those of the tiller.

*Effect of the vigour of seedling at planting on the average yield per ear-head.*—The vigour of the seedling at planting influences the average yield per earhead within certain limits. The term vigour, however, in the case of a rice seedling is very vaguely used. In common practice it means a thick stemmed healthy seedling with proportionately good height and breadth of leaf for its age, and having a green or dark green colour. In 1919 trials made with fairly good and specially sturdy seedlings did not give any definite indications. The experiments of that year were made without controlling the distance and the number per bunch planted. The fields were transplanted (in all the plots) under trial according to the cultivators' practice. Hence the figures are not strictly comparable. However, it is well to record them as they are :—

Treatment.	1919. Average yield per panicle. (Average of 1,000 panicles.) Tolas.
Strong : two seedlings per bunch ..	0.193
Weak : do. ..	0.207
Strong : single seedling planting ..	0.222
Weak : do. ..	0.199
Strong : single seedling planting ..	0.263
Weak : do. ..	0.236
Strong : do. ..	0.235
Weak : do. ..	0.282

Treatment.	1919.	
	Average yield per panicle. (Average of 1,000 panicles.)	
	Tolas.	
Strong seedlings : bunch planting	..	0·191
Ordinary seedlings : do.	..	0·187
Strong seedlings : do.	..	0·239
Ordinary seedlings : do.	..	0·199
Strong seedlings : do.	..	0·246
Weak seedlings : do.	..	0·211

In five cases out of the seven, the strong seedlings have on an average produced a bigger panicle (on an average of thousand panicles). In one case they are almost the same size, while in one, the weak have produced a bigger panicle. Although these experiments were not conducted with precision, it may be said by studying the figures that the stronger seedlings usually produced a bigger panicle. The average of all cases shows yield of 0·227 tolas per earhead from strong seedlings and of 0·217 tolas per earhead with ordinary or weak seedlings.

In 1920 the work was conducted with great care. The plots were planted out with an equal number (8) of culms per bunch with equal spacing. The results are given below :—

Treatment.	1920.	
	Average yield per panicle.	
	Tolas.	
1. Seedlings without <i>rab</i> —		
(a) 1 to $2\frac{1}{2}$ m.m. thick	..	0·175
(b) 3 to $4\frac{1}{2}$ m.m. thick	..	0·166
2. Seedlings with <i>rab</i> —		
(a) 1 to $2\frac{1}{2}$ m.m. thick	..	0·208
(b) 3 to $4\frac{1}{2}$ m.m. thick	..	0·226
(c) 5 to $6\frac{1}{2}$ m.m. thick	..	0·164
(d) 6 to $7\frac{1}{2}$ m.m. thick	..	0·172
(e) 6 to $7\frac{1}{2}$ m.m. thick	..	0·218
3. Seedlings with <i>rab</i> —		
(a) 1 to $2\frac{1}{2}$ m.m. thick	..	0·197
(b) 3 to $4\frac{1}{2}$ m.m. thick	..	0·227
(c) 6 to $7\frac{1}{2}$ m.m. thick	..	0·201

These results would seem to indicate that any result in final size of earhead which is due to the vigour of seedlings is completely masked by other causes.

In 1921 a similar series of experiments was undertaken but the vigour of the seedling will be shown by the treatment which the seed-bed received of which it is a part. Six seedlings were planted per bunch and the bunches were planted twelve inches apart in both directions.

Treatment.	1921.	
	Average yield per panicle.	
		Tolas.
1. (a) Seedlings without <i>rab</i> .. ..	..	0·218
(b) Seedlings with a quarter usual amount of <i>rab</i> ..	..	0·197
(c) Seedlings with half the usual amount of <i>rab</i> ..	..	0·213
(d) Seedlings with full amount of <i>rab</i> .. ..	..	0·210
2. (a) Seedlings without <i>rab</i> .. ..	..	0·229
(b) Seedlings with a quarter usual amount of <i>rab</i> ..	..	0·221
(c) Seedlings with half the usual amount of <i>rab</i> ..	..	0·223
(d) Seedlings with full amount of <i>rab</i> .. ..	..	0·201
3. (a) Seedlings without manure .. ..	..	0·206
(b) Seedlings with 40 lbs. Nitrogen per acre (as Sulphate of Ammonia) .. ..	..	0·221
(c) Seedlings with 80 lbs. Nitrogen per acre (as Sulphate of Ammonia) .. ..	..	0·216
4. (a) Seedlings 1 to 2½ m.m. thick .. ..	..	0·213
(b) Seedlings 7 to 8 m.m. thick .. ..	..	0·229

Taking these three years together the conclusions seem inevitable that the vigour of the seedlings at the time of transplanting is a matter of minor importance in determining the size of the earhead in the transplanted crop. A pot experiment in 1921, planting single seedlings gave an equally uncertain result as follows :—

Treatment.	Average yield per earhead.	
	Grammes.	Grammes.
1. Seedlings with <i>rab</i> .. ..	1·99	1·71
2. Seedlings without <i>rab</i> .. ..	1·74	1·83

*Effect of the distance of bunches in planting on the average yield per earhead.*—In each case six seedlings were placed at varying distances. In 1919 the results were calculated for 1,000 heads, in 1920 and 1921, the whole of the earheads in the plot were examined :—

Distance of bunches.	Average yield per earhead.		
	1919	1920	1921
	Tolas.	Tolas.	Tolas.
6 inches apart .. ..	0·269	0·089	0·144
9 inches apart .. ..	0·219	0·163	0·215
12 inches apart .. ..	0·227	0·193	0·253
15 inches apart .. ..	0·287	0·215	0·281
18 inches apart .. ..	0·274	0·246	0·291
21 inches apart .. ..	0·280	.....	.....
24 inches apart .. ..	0·298	0·262	0·289
27 inches apart .. ..	0·295	.....	.....
30 inches apart .. ..	0·310	.....	.....
33 inches apart .. ..	0·338	.....	.....
36 inches apart .. ..	0·296	.....	.....

These figures show a gradual increase in the size of earhead as the bunches are placed further and further apart. The result is not so clear in the figures for 1919, as in those of the two following years, but the general tendency is evident throughout.

A question arises as to how far the increase in size of earhead is affected by the number of culms which in the wider planting especially arise from tillers (see pages 38-39), and the following experiment throws light on this point. Five bunches (of six seedlings each) planted at varying intervals in 1921 were thoroughly studied and every earhead examined with the following result :—

(M.—Earhead on main culm ; T.—Earhead on first tiller. TT.—Earhead on secondary tillers arising from the first tiller ; T2.—Earhead on second tiller ; T3.—Earhead on third tiller.)

Distance of bunches.	Ear-heads in five bunches.	Number of earheads borne in 5 bunches.						Number of flowers per panicle.					
		M.	T.	TT.	T2	T3	Others.	M.	T.	T.T.	T2	T3	Others.
6 inches apart ..	29	28	1	..	..	..	..	111	77	..	..	..	..
9 inches apart ..	41	29	11	..	1	..	..	200	166	..	158	..	..
12 inches apart ..	59	27	16	3	10	1	2	277	272	289	265	346	265
15 inches apart ..	78	30	22	4	16	4	2	315	304	207	285	224	218
18 inches apart ..	95	28	25	7	20	9	6	402	366	264	300	303	261

The following conclusions seem to arise from this experiment :—

1. The average number of flowers in the earhead on the main culm increases with the increase in the distance of planting. The same result is almost equally clear in the size of the earhead with each type of tiller.

2. The earheads are fairly uniform in size when the bunches are twelve inches apart. At less and more than this distance, the earheads on the tillers are smaller than those on the main culm. As it is obviously of importance to get all the earheads as equal in size as possible this affords a measure of the most suitable distance for transplanting, other things being equal.

It is interesting to compare the results of these experiments on the effect of distance in transplanting on the size of and yield per earhead with those previously recorded (page 30), on the effect of distance in transplanting on the number of ear-bearing culms per unit area.

*Effect of cultivation given to the field on the average yield per earhead.*—The earhead is very slightly affected by the amount of cultivation given



Earheads tend to increase in size with the distance of planting.

to the field, as the following figures obtained in 1920 and 1921 seem to show :—

Cultivation.	Average yield per earhead.	
	1920	1921
1 ploughing in wet and planking	Tolas. ·230	Tolas. ·205
3 do. do.	·226	·224
5 do. do.	·224	·234
7 do. do.	·221	·235
9 do. do.	·217	·252
11 do. do.	·241	·254

In 1920 the average yield per earhead is rather irregular from plot to plot, but in 1921 the yield slowly and slightly increases with the number of ploughings given, showing that better puddling enables the plant more easily to satisfy its requirements for complete growth.

*Effect of manurial treatment on the average yield per earhead.*—The effect of manuring has already been discussed so far as its influence on tillering is concerned (page 32) and it has been found that nitrogenous manure has great influence in increasing the ear-bearing culms per unit area. It is now to be seen whether with the increase of ear-bearing culms there is also a simultaneous increase in the average yield per earhead. The results of experiments during three years are given below :—

The experiments conducted in the year 1919 were simply made so as to get an idea as to whether increased manuring produced a very marked effect on the size and yield of the panicles. All the manured plots received first a substantial dressing of eighty head loads of green leaf manure per acre and this must be understood in all such plots, and then, in addition, a dressing of Sulphate of Ammonia and Superphosphate. These latter manures were always in the same proportion to one another, namely five pounds of Sulphate of Ammonia (equal to one pound of nitrogen) to seven pounds of Superphosphate. The average yield is determined from one thousand earheads.

Manure applied per acre.		1919.
		Average yield per panicle
		Tolas.
1.	{ (a) No manure	·0·247
	{ (b) " " " " " "	·0·175
	{ (c) " " " " " "	·0·215
2.	{ 200 lbs. Sulphate of Ammonia	·0·261
	{ 280 lbs. Superphosphate	
3.	{ 225 lbs. Sulphate of Ammonia	·0·259
	{ 315 lbs. Superphosphate	
4.	{ 275 lbs. Sulphate of Ammonia	·0·240
	{ 385 lbs. Superphosphate	
5.	{ 300 lbs. Sulphate of Ammonia	·0·215
	{ 420 lbs. Superphosphate	



Manure applied per acre.		1919. Average yield per panicle. Tolas.	
6.	{ 325 lbs. Sulphate of Ammonia .. 455 lbs. Superphosphate .. }	{ .. .. }	0·253
7.	{ 375 lbs. Sulphate of Ammonia .. 525 lbs. Superphosphate .. }	{ .. .. }	0·248
8.	{ 400 lbs. Sulphate of Ammonia .. 560 lbs. Superphosphate .. }	{ .. .. }	0·277

These results, though obviously not conclusive, certainly indicate a very small effect of manure in increasing the yield per earhead. It was decided in the following year to carry this experiment further with the modification that no green leaf manure was used, all the fertiliser being added in the form of Sulphate of Ammonia and Superphosphate, the quantity of the latter being now always twice the weight of the Sulphate of Ammonia used. The results were as follows:—

Manures applied per acre.		1920. Average yield per panicle. Tolas.	
<i>Experiment I.</i> —Four culms per bunch; bunches 18 inches apart—			
1.	{ (a) } No manure { .. .. { (b) } { .. .. { (c) } { .. .. }	{ .. { .. { .. }	0·316 0·349 0·294
2.	{ 300 lbs. Sulphate of Ammonia .. 600 lbs. Superphosphate .. }	{ .. .. }	0·248
3.	{ 325 lbs. Sulphate of Ammonia .. 650 lbs. Superphosphate .. }	{ .. .. }	0·274
4.	{ 350 lbs. Sulphate of Ammonia .. 700 lbs. Superphosphate .. }	{ .. .. }	0·292
5.	{ 475 lbs. Sulphate of Ammonia .. 950 lbs. Superphosphate .. }	{ .. .. }	0·244
6.	{ 500 lbs. Sulphate of Ammonia .. 1,000 lbs. Superphosphate .. }	{ .. .. }	0·259

*Experiment II.*—Four culms per bunch; bunches 12 inches apart—

1.	{ (a) } No manure { .. .. { (b) } { .. .. }	{ .. { .. { .. }	0·250 0·250
2.	{ 100 lbs. Sulphate of Ammonia .. 200 lbs. Superphosphate .. }	{ .. .. }	0·250
3.	{ 150 lbs. Sulphate of Ammonia .. 300 lbs. Superphosphate .. }	{ .. .. }	0·230
4.	{ 200 lbs. Sulphate of Ammonia .. 400 lbs. Superphosphate .. }	{ .. .. }	0·220

The results thus recorded are an absolute confirmation of those obtained in the previous year. Any effect of the manure on the weight per earhead is absolutely masked by other influences, and its influence would appear to be slight.

The experiments were repeated and extended in 1921, with the additional advantage that they were conducted with a pure line strain of *Kolamba* rice, in which, of course, there was a greater security for uniform results than previously.

*Experiment I. Effect of increasing doses of manure.*—Planting 4 culms per bunch; bunches twelve inches apart.

Plot No.	Manure applied per acre.	1921.	
		Average yield per panicle.	
		Tolas.	
1.	No manure.	{ <sup>a</sup>	0·196
		{ <sup>b</sup>	0·200
2.	25 lbs. Sulphate of Ammonia :- 37·5 lbs. Superphosphate	*	0·185
3.	50 lbs. do. :- 75 lbs. do.		0·190
4.	75 lbs. do. :- 112·5 lbs. do.		0·197
5.	100 lbs. do. :- 150 lbs. do.		0·218
6.	125 lbs. do. :- 187·5 lbs. do.		0·214
7.	150 lbs. do. :- 225 lbs. do.		0·216
8.	300 lbs. do. :- 450 lbs. do.		0·223
9.	400 lbs. do. :- 600 lbs. do.		0·197
10.	500 lbs. do. :- 750 lbs. do.		0·201

*Experiment II. Effect of increasing doses of manure.*—Planting 4 culms per bunch; bunches twelve inches apart.

Plot No.	Manure applied per acre.	1921.	
		Average yield per panicle.	
		Tolas.	
1.	No manure.	{ <sup>a</sup>	0·229
		{ <sup>b</sup>	0·205
2.	25 lbs. Sulphate of Ammonia :- 37·5 lbs. Superphosphate		0·239
3.	50 lbs. do. :- 75 lbs. do.		0·234
4.	75 lbs. do. :- 112·5 lbs. do.		0·240
5.	100 lbs. do. :- 150 lbs. do.		0·241
6.	125 lbs. do. :- 187·5 lbs. do.		0·243
7.	150 lbs. do. :- 225 lbs. do.		0·230

*Experiment III. Effect of increasing doses of Phosphoric Acid.*—Planting 4 culms per bunch; bunches 15 inches apart in 1920; 12 inches in 1921.

Plot No.	Manures applied per acre.	Average yield per earhead.	
		1920.	1921.
1	No Manure	0·280	0·227
2	200 lbs. Sulphate of Ammonia	0·240	0·212
	200 lbs. Superphosphate		
3	200 lbs. Sulphate of Ammonia	0·280	0·247
	400 lbs. Superphosphate		
4	200 lbs. Sulphate of Ammonia	0·240	0·257
	600 lbs. Superphosphate		
5	200 lbs. Sulphate of Ammonia	0·280	0·254
	800 lbs. Superphosphate		
6	200 lbs. Sulphate of Ammonia	0·250	0·240
	1,000 lbs. Superphosphate		

\* Superphosphate contains 26·64 % Phosphoric acid.

The general result of all these experiments is to confirm what has already been indicated as the result of the two previous years' experience. The effect of increased manuring, or of an increased phosphatic element in the manuring, is not reflected constantly in an increased size of earhead. Such manuring is effective in increasing the yield, as will be shown later, but this increase is not gained in any constant manner by an increase in the size of the panicle.

*Effect of the Origin of Culm.*—(That is to say whether it is a culm from the main plant or from a tiller), *on the average yield per earhead.* The size of the earheads on a particular plant is not by any means the same. As a rule the mother culm (or the culm derived from the main plant) will give the largest earhead, but this is by no means always the case. Not infrequently the earhead derived from the first or even the second tiller is the biggest, and this condition of things usually prevails with five to ten per cent. of plants and has never been found in more than twenty per cent. of cases. The earheads which are bigger than those of the mother culm are usually those on the first tiller, though this is not always the case. The second or third tiller, or the secondary tiller developed on the first, generally produces a smaller panicle. This might perhaps be expected, owing to the fact that the panicles derived from tillers do not usually have so long to develop as those derived from the mother culms.

A systematic study of the earheads of different orders of growth was, therefore, undertaken in 1921 purposely with a view to determine how far tillering should be promoted in rice cultivation. There are certain environmental conditions such as space and manuring, under which plants tiller profusely, but if this tillering is associated with smaller earheads, it might on the whole result in reducing the yield.

For this purpose five bunches from each of forty-two plots treated differently were uprooted between one and two weeks before harvesting the crop, and the panicle of each of the culms was measured in length and was described. These panicles were then stored in paper bags for counting the flowers on them at some convenient time. Side by side the length and girth of the lowest internode above ground and height of the culm were measured and recorded.

The mother culms are easily detected in bunches. They are the original seedlings transplanted. These, as has been shown before (page 13), form an internode below ground with remnants of the old and also the new rooting system. Culms showing the underground internodes with the old root system, are mother culms. On this mother are borne the tillers and these are recognised as the first, second, third, fourth, etc., from the point of their attachment to the mother culm. The lower the attachment the older is the tiller. In some cases a tiller produces a tiller which comes off with the tiller when it is pulled out from the mother culm. In this way it was possible to determine the origin of the different earheads in a bunch with certainty. In all, more than 2,000 earheads were examined and the analysis of the results is shown in the following tables.

*A\*—Effect of Distance apart of the Bunches.*—In this experiment six culms were transplanted in each bunch.

Distance of Bunches.	Ear-heads in 5 bunches.	Classification of earheads.						Number of flowers per panicle (average).					
		M.	T.	TT.	T2.	T3.	Others.	M.	T.	TT.	T2.	T3.	Others.
1. Six inches	29	28	1	..	..	..	..	111	77	..	..	..	..
2. Nine inches	41	29	11	..	1	..	..	200	166	..	158	..	..
3. Twelve inches	59	27	16	3	10	1	2	277	272	287	265	346	265
4. Fifteen inches	78	30	22	4	16	4	2	315	304	207	285	234	213
5. Eighteen inches	95	28	25	7	20	9	6	402	366	264	300	303	261

\* In the following tables—M=Earhead on Main or Mother Culm; T=Earhead on First Tiller; TT=Earhead on secondary Tiller arising from First Tiller; T2=Earhead on Second Tiller; T3=Earhead on Third Tiller, and so on.

*B.—Effect of Number of Seedlings per Bunch.*—In this experiment the bunches were nine inches apart in experiments I and II and twelve inches apart in Experiment III.

Seedlings per bunch.	Ear-heads in 5 bunches.	Classification of earheads.						Number of flowers per panicle (average).					
		M.	T.	TT.	T2.	T3.	Others.	M.	T.	TT.	T2.	T3.	Others.
<i>Experiment I.</i>													
Two seedlings	20	11	8	..	1	..	..	345	297	..	160	..	..
Three seedlings	24	13	8	..	3	..	..	266	217	..	282	..	..
Four seedlings	32	20	9	..	3	..	..	262	202	..	163	..	..
Five seedlings	34	24	8	..	2	..	..	228	164	..	169	..	..
Six seedlings	32	29	3	..	..	..	..	202	173	..	..	..	..
Eight seedlings	44	42	2	..	..	..	..	140	78	..	..	..	..
Twelve seedlings	59	58	1	..	..	..	..	137	72	..	..	..	..
<i>Experiment II.</i>													
Two seedlings	19	8	7	1	2	1	..	365	275	215	326	..	260
Three seedlings	33	13	12	..	7	1	..	383	271	..	268	244	..
Four seedlings	39	18	13	..	6	2	..	342	269	..	316	206	..
Five seedlings	40	27	12	..	1	..	..	251	140	..	196	..	..
Six seedlings	36	30	6	..	..	..	..	252	187	..	..	..	..
Eight seedlings	46	38	7	..	1	..	..	213	152	..	140	..	..

Seedlings per bunch.	Ear-heads in 5 bunches.	Classification of earheads.						Number of flowers per panicle (average).					
		M.	T.	TT.	T2.	T3.	Others.	M.	T.	TT.	T2.	T3.	Others.
<i>Experiment III.</i>													
Five seedlings ..	43	25	12	..	6	..	..	246	241	..	190	..	..
Six seedlings ..	45	28	13	..	4	..	..	259	193	..	204	..	..
Eight seedlings ..	59	39	18	..	2	..	..	286	193	..	180	..	..
Twelve seedlings ..	60	51	8	..	1	..	..	221	202	..	182	..	..

*C.—Effect of Tillering before Transplanting.*—All the bunches were planted twelve inches apart. The number of culms planted was equal in each case.

Tillers per Seedling.	Ear-heads in 5 bunches.	Classifications of earheads.						Number of flowers per panicle (average).					
		M.	T.	TT.	T2.	T3.	Others.	M.	T.	TT.	T2.	T3.	Others.
1. Three ..	35	5	5	5	5	4	11	410	419	818	319	310	362
2. One ..	41	14	13	..	11	3	..	431	324	..	317	238	..
3. None ..	42	17	14	1	6	3	1	335	298	301	288	148	308

*D.—Effect of Rab Treatment in the Seedbed.*—All the bunches were planted twelve inches apart.

Treatment of Seedbed.	Ear-heads in 5 bunches.	Classification of earheads.						Number of flowers per panicle (average).					
		M.	T.	TT.	T2.	T3.	Others.	M.	T.	TT.	T2.	T3.	Others.
1. Full quantity of <i>rab</i> ..	53	30	20	..	3	..	..	277	214	..	128	..	..
2. Half quantity of <i>rab</i> ..	39	31	8	..	..	..	..	271	211	..	..	..	..
3. Quarter quantity of <i>rab</i> ..	39	26	11	..	2	..	..	232	168	..	..	186	..

*E.—Effect of Vigour of Seedlings.*—The vigour was judged by the thickness of the seedlings. The bunches were planted twelve inches apart, and six seedlings per bunch were planted.

Thickness of seedlings.	Ear-heads in 5 bunches.	Classification of earheads.						Number of flowers per panicle (average).					
		M.	T.	TT.	T2.	T3.	Others.	M.	T.	TT.	T2.	T3.	Others.
1. 7 to 8 millimeters ..	49	30	19	..	..	..	..	344	175	..	..	..	..
2. 1 to 2½ millimeters ..	40	12	10	2	7	2	7	330	268	263	288	361	278

*F.—Effect of Manure in the Transplanted Crop.*—The manure was applied as a mixture of Sulphate of Ammonia and Superphosphate in the proportion of one part of Nitrogen to two of Phosphoric acid. Four seedlings were planted per bunch, bunches twelve inches apart.

Plot No.	Manure per acre.	Ear-head in 5 bunches.	Classification of earheads.							Number of flowers per panicle (average).						
			M.	T.	TT.	T2.	T3.	T4.	Others.	M.	T.	TT.	T2.	T3.	T4.	Others.
1	No manure.	52	20	20	..	9	1	..	2	292	220	..	228	116	..	200
2	No manure.	49	18	16	..	9	..	..	6	201	161	..	155	..	..	
3	1,250 lbs. mixture ..	78	16	16	9	14	6	3	14	296	267	235	266	182	231	231
4	1,000 lbs. mixture ..	85	19	18	2	17	13	1	15	266	233	195	229	257	110	196
5	750 lbs. mixture ..	26	21	21	2	18	7	2	15	316	276	192	263	244	246	..
6	875 lbs. mixture ..	62	18	18	2	15	4	2	3	300	236	223	200	230	242	..
7	312.5 lbs. mixture ..	61	20	19	1	13	7	..	1	263	216	193	165	168	..	127
8	250 lbs. mixture ..	50	18	17	3	10	2	..	..	295	204	145	182	128	..	..
9	187.5 lbs. mixture ..	56	19	18	2	14	3	..	..	263	206	141	208	134	..	..
10	125 lbs. mixture ..	54	23	16	..	9	3	1	2	239	191	185	205	136	..	106
11	62.5 lbs. mixture ..	53	24	16	..	7	3	1	2	208	136	..	171	255	211	150

An examination of the average number of flowers per panicle shows that manuring does not very largely increase the yield per earhead of the mother panicle. The mother panicles of the manured plots are, in general, better than those of the unmanured, but what is more advantageous is that the higher the dose of the manure the difference between the yields of the tillers and the mother decreases and they become more and more equal in yield. This is nearing the condition which would naturally be aimed at in growing a maximum crop.

Not only does higher manuring increase the number of panicles per unit area, but it also, side by side, brings all the panicles nearer together in yield.

The general conclusions that can be drawn from this study are :—

1. The earheads of the mother stalk are generally speaking bigger than those of the tillers.
2. By adjusting distance, which would vary for different tracts, all earheads whether of the mother culm or of the tillers, can be approximately brought to an equal yield.
3. By planting too many seedlings per bunch the average yield per earhead of the mother culm is considerably reduced.
4. As regards the effect of changes in the vigour of seedlings on the earheads nothing can yet be said with definiteness.

5. Manuring has the effect of feeding the tillers better and thus bringing the yield of all earheads nearer to one another.

6. The best plan, therefore, seems to be to produce earheads by planting as few seedlings per bunch as is warranted by the climatic conditions, and to manure the crop to increase tillering and get even earheads. To get a larger number of mother earheads by planting many seedlings per bunch would lead to the reduction in the average yield per earhead.

## CHAPTER VI.

### FACTORS INFLUENCING THE YIELD OF RICE.

In the preceding chapters it has been shown how the growth of the individual parts, such as stem, leaves, tillers, earheads, etc., of the rice plant are affected by the environment. It now remains to see how far each of the conditions, whether alone or with others, determines or can be made to determine the yield of rice per unit area, for, to obtain the maximum yield per acre is the ultimate end of all the work in hand.

It is quite obvious that the yield of rice per unit area is made up of a product of two factors, namely, (I) the number of earheads per unit area, (II) average yield per earhead. Now taking each factor separately it will be seen from the foregoing studies that *the number of earheads per unit area* may be affected by:—

(1) the number of plants planted as determined by either the number of seedlings planted in each bunch, or the spacing allotted to each bunch.

(2) The number of tillers produced as determined by:—

(a) Age of seedlings at the time of transplanting.

(b) Number of plants planted per unit area modified either by varying the number of seedlings per bunch or changing the distance.

(c) Vigour of seedlings.

(3) The capacity of the land to feed plants as brought about by either one or more of the following:—

(a) Space allotted.

(b) Chemical, physical and biological conditions of the soil.

(c) Artificial changes in the chemical, physical and biological conditions brought about by:—

(i) Cultural operations, transplanting or its alternatives, the number of ploughings, and hot weather ploughing.

(ii) Manuring with various elements of plant food in various forms.

(4) Water supply and drainage.

(5) Variety and strain of the crop.

(6) Death or injury of plants during the growth.

On the other hand *the average yield per earhead* is affected by:—

(1) Total number of plants produced per unit area by one or more of the above causes.

(2) Extent of plant food supply, as brought about by one or more causes referred to above.

(3) The extent of sterile grains in an average earhead.

The part which the different conditions play will now be discussed.

*Effect on the Yield of Rice of the Age of Seedlings at the time of transplanting.*—It will be recognised that the yield of the rice crop is considerably affected by the age at which the seedlings are transplanted. At present the stage at which they are fit for transplanting is determined by a superficial examination of the standing crop of seedlings in the seed-bed. This is usually, under the normal conditions of growing seedlings, between thirty-five and forty-five days old, but it must be remembered that it is not the actual age so much as the stage of development which will determine the readiness of the plants for the operation. Hence the question of the age must be determined really with reference to the stage of growth and this will depend on the way in which the seedlings are grown.

There are a number of possible methods of determining the best stage. One, which at first sight seemed possible was by chemical analysis, and with a view to see how far the method was feasible seedlings were analysed at intervals during the seasons of 1920 and 1921. The actual figures of the analysis will be found in Appendix 1\*, which extend from seedlings of fifteen days to those of sixty-four days, both where the seeds were sown thinly and where they were sown thickly.

It would appear from these statements that there is no definite stage in the composition which can be considered to mark the time when transplanting should be done, and as a means of determining this point the method fails. The data are, however, of importance as illustrating the changes in the composition of the rice plant as a whole throughout the seedling stage.

Taking the usual growth of the seedlings as it occurs in an average seedbed in the north Konkan in June, the data furnished on pages 27 and 28 show that there is a slight decrease in the number of tillers produced in the field as the age of transplanting advances up to an age of thirty-five to forty-five days. After this there is again a tendency for the number of tillers to increase. This is the stage at which the plants usually produce their first internode above the ground in the seedbed, and suggests that this may form the maximum limit for getting the best results. We will see how far this agrees with the actual results obtained on 1919-1920 and 1921 in the size of the earhead, in the relative number of earheads per unit area and in the actual yield obtained calculated to one acre.

In 1919, the results were of a preliminary character and it was then not possible to obtain a strain of Kolamba rice grown in pure line for the experiment.

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\* The analysis were kindly undertaken by Mr. D. L. Sahasrabudhe, M.Sc., M.Ag., Agricultural Chemist to the Government of Bombay, and the authors' grateful thanks are due to him.



The figures obtained were, however, as follows :—

Treatment.	Average yield per head in tolas.	Earheads per unit area.	Results per acre.	
			Grain.	Straw.
Planting seedlings 16 days old..	·35	1,492	lbs. 3,389	lbs. 3,696
Do. 18 do. . .	·265	2,440	3,177	3,432
Do. 23 do. . .	·254	2,405	3,349	3,630
Do. 27 do. . .	·247	2,391	3,854	4,158
Do. 35 do. . .	·230	2,358	3,455	3,564
Do. 43 do. . .	·210	2,147	3,204	3,564
Do. 51 do. . .	·189	2,342	2,537	2,640
Do. 60 do. . .	·162	2,865	2,544	2,640
Do. 64 do. . .	·167	2,879	2,544	2,640
Do. 73 do. . .	·136	2,907	2,451	3,168

The figures indicate that the average yield per earhead decreases rapidly as the age of seedlings at transplanting increases. It is recognised that this result is complicated by the fact that the planting of older seedlings meant also planting later in the season. The number of earheads per unit area (which corresponds closely with the amount of tillering) increases, however, and, in fact, the two factors of yield are inversely related. The maximum yield will, therefore, be obtained at a point when the curves representing these two factors cross one another, and this is represented by the age of twenty-seven days, or a little before any above ground node appears on the plant.

In 1920, the experiment was repeated with one complication. It was suggested that the older seedlings are inferior because, the growing point has a tendency to come above ground, after which it is more liable to be injured in transplanting. But the thicker the seed rate in the seedbed, the earlier do the seedlings produce nodes above ground, and therefore, if we have two seedbeds with different seed rates, the more thickly planted one will require planting out earlier than the other. The seed rates used were 240 pounds and 120 pounds per acre of seedbed, and the results were as follows :—

*Thicker seed rate (240 pounds seed per acre of seedbed.)*

Treatment.	Average yield per earhead in tolas.	Earheads per unit area.	Yield per acre.	
			Grain.	Straw.
Planting seedlings 16 days old..	·221	371	lbs. 2,559	lbs. 3,050
Do. 24 do. . .	·198	332	2,500	2,700
Do. 32 do. . .	·169	355	2,568	2,757
Do. 40 do. . .	·181	370	2,673	2,947
Do. 48 do. . .	·150	448	2,430	2,692
Do. 56 do. . .	·130	438	2,153	2,059
*Do. 64 do. . .	·123	457	2,393	2,013

\* This plot is hardly comparable with the others as it was somewhat more favourably situated.

*Thinner seed rate (120 pounds seed per acre of seedbed).*

Treatment.	Average yield per earhead in tolas.	Earheads per unit area.	Yield per acre.	
			Grain.	Straw.
			lbs.	lbs.
Planting seedlings 16 days old..	·204	354	2,832	3,400
Do. 24 do. ...	·215	357	2,951	3,207
Do. 32 do. ...	·199	334	2,421	2,957
Do. 40 do. ...	·176	316	2,208	2,605
Do. 48 do. ...	·173	432	2,451	3,007
Do. 56 do. ...	·160	394	2,332	2,600
Do. 64 do. ...	·154	358	2,197	2,270

The results, as reported, do not accord with the theory on which the experiment was based. The seedlings which gave the best result were older (40 days) in the more thickly planted seedbed. However, in the following year (1921) the experiment was repeated, though owing to climatic reasons (absence of heavy rain) transplanting could not be undertaken with seedlings less than thirty-five days old. The results are as follows :—

*Thicker seed rate (240 pounds seed per acre of seedbed).*

Treatment.	Average yield per earhead in tolas.	Earheads per acre.	Yield per acre.	
			Grain.	Straw.
			lbs.	lbs.
Planting seedlings 35 days old..	·206	417,600	2,134	2,130
Do. 40 do. ...	·222	408,000	2,251	2,196
Do. 48 do. ...	·198	400,000	1,961	1,769
Do. 52 do. ...	·186	435,100	2,006	1,800
Do. 56 do. ...	·176	469,600	2,060	1,775
Do. 60 do. ...	·161	466,800	1,882	1,800
Do. 64 do. ...	·158	452,200	1,781	1,575

*Thinner seed rate (120 pounds seed per acre of seedbed).*

Treatment.	Average yield per earhead in tolas.	Earheads per acre.	Yield per acre.	
			Grain.	Straw.
			lbs.	lbs.
Planting seedlings 35 days old..	·253	425,300	2,661	2,636
Do. 40 do. ...	·249	372,300	2,314	2,050
Do. 48 do. ...	·213	413,900	2,189	1,904
Do. 52 do. ...	·184	389,400	1,771	1,719
Do. 56 do. ...	·165	457,200	1,879	1,644
Do. 60 do. ...	·153	454,200	1,727	1,775
Do. 64 do. ...	·139	459,500	1,592	1,719

These figures confirm the results of the previous year. With the thicker seedbed, the best results are obtained with planting seedlings not less than forty days old ; with the thinner seed rate, the best yield is obtained with seedlings not more than thirty-five days old. Thus, on the whole, with the thinner seed rate the seedlings should be planted at an earlier stage, and not *vice versa* as the theory would suggest.

The following general conclusions may be drawn as the result of the three years' experiments recorded :—

1. The average yield per earhead decreases with the increase in the age of the seedlings at transplanting.

2. The number of earheads per unit area increases with the increased age of the seedling at transplanting.

3. These two factors of yield being inversely correlated, the maximum yield is obtained at an intermediate age. In theory, it would be when their multiplication gives the highest figure, in practice (obviously as a result of other factors present) this is not quite the case, though the highest yield is always obtained, as already stated, at an intermediate age.

4. The greatest decrease in yield below the maximum due to seedlings as old as sixty-four days was as follows :—

1919	..	34.0 per cent.
1920	..	25.6 per cent.
1921	..	40.2 per cent.

5. The optimum age of planting seedlings, other conditions being normal in the Konkan is certainly below forty days, and this is the greatest age at which transplanting can be safely done. The greatest decrease in yield below the maximum due to the seedlings being left to forty days old (forty-three days in 1919) was as follows :—

1919	..	16.9 per cent.
1920	..	25.2 per cent.
1921	..	13.0 per cent.

The reason of the worse results with old seedlings has not, therefore, been cleared up. It is certainly not that the growing point has come above the ground. It has been suggested that the tillers, with old seedlings, do not get time to develop fully. This is, so far a guess, but if true, it should be possible to overcome it by applying a dose of a suitable fertiliser.

*Effect on the yield of rice of the vigour of seedlings at the time of transplanting.*—It is a universal belief among rice growers that vigorous and sturdy seedlings give better results when planted out. The actual results of vigour in the seedlings on the tillering capacity of the plants and on the yield per earhead has been already described (pages 23 and 43 respectively). But the term 'Vigorous' itself is not easily defined. A seedling with a thick stem, broad leaves, and with a dark green colour is usually considered vigorous, and this is what is used as a basis in the following experiments. Where an actual measure

of the vigour is required, the relative thickness of the stem of the seedling at the base is taken as the measure.

It will be recalled that the size of the earhead is only determined to a very minor extent by the vigour of the seedlings (pages 43-44). It remains now to see how the total yield is affected by the type of seedlings used. Taking the mean of seven sets of experiments in 1919, the following figures were obtained :—

Kind of seedlings.	Average yield per earhead tolas.	Yield per acre.	
		Grain.	Straw.
Weak seedlings .. .. .	·217	lbs. 3,627	lbs. 3,333
Vigorous seedlings .. .. .	·227	3,131	2,999

While therefore the earheads from the strong seedlings are larger (by four per cent.) than those from the weak, yet the yield is distinctly less per acre, and the weak seedlings have given a considerably (13·7 per cent.) higher yield. This is so completely at variance with the general opinion that the matter was more carefully investigated in the following year.

In 1920, therefore, the vigour of the plants was measured in two ways. First this was done by determining the thickness of the stem of the seedling, and second it was assumed from the treatment of the seedbed. In all cases the plots were transplanted with an equal number (six) of seedlings per bunch, the bunches being twelve inches apart.

Thickness of seedling.	Number of earheads per unit area.	Yield per earhead tolas.	Yield per acre.	
			Grain.	Straw.
6 to 7½ mm. .. .. .	374	·218	lbs. 3,357	lbs. 3,918
3 to 4½ mm. .. .. .	364	·226	3,568	4,259
1 to 2½ mm. .. .. .	361	·208	3,372	4,028

These results do not show any material advantage to the thicker seedlings at least when all have been grown in the same seedbed. There is, however, one aspect with regard to the vigour of seedlings which gives strong seedlings a considerable advantage. This is the physical and mechanical advantage that the seedlings have, which are better able to withstand the force of the flood water by which weak seedlings are easily overpowered.

The other criterion of vigour, namely, the treatment of the seedbed, was used for experiments in 1920 and 1921. The beds used had been either treated with no *rab* or with varying quantities of *rab* material, a change which is always immediately noticeable in the vigour of

the plants. In 1920 eight and in 1921 six seedlings were planted per bunch.

Treatment of seedbed.	Earheads per unit area.	Average yield per earhead tolas.	Yield per acre.	
			Grain.	Straw.
1920.				
1. No <i>rab</i> on seedbed (thickness 1 to 2½ mm.) ..	393	·175	2,687	2,954
2. <i>Rab</i> on seedbed (thickness 5 to 6½ mm.) ..	380	·164	2,607	3,107
3. <i>Rab</i> on seedbed (thickness 6 to 7½ mm.) ..	337	·172	2,523	3,272
1921.				
1. No <i>rab</i> on seedbed ..	363	·218	1,986	1,843
2. One half usual <i>rab</i> on seedbed ..	369	·213	1,945	1,806
3. Full quantity of <i>rab</i> on seedbed ..	396	·210	2,078	2,085

It is evident from these results that seedlings securing better treatment in the seedbed do not give a constantly higher yield of grain per acre. However in a similar experiment where the increased vigour in the seedbed was obtained by a dressing of Sulphate of Ammonia, a slightly different result was obtained.

Treatment of seedbed.	Earheads per unit area.	Average yield per earhead tolas.	Yield per acre.	
			Grain.	Straw.
1920.				
1. No manure ..	366	·189	2,832	3,850
2. 200 lbs. Sulphate of Ammonia per acre ..	412	·187	3,245	4,200
3. 400 lbs. Sulphate of Ammonia per acre ..	427	·206	3,333	4,150
1921.				
1. No manure ..	444	·206	2,274	2,130
2. 200 lbs. of Sulphate of Ammonia per acre ..	448	·221	2,493	2,351
3. 400 lbs. Sulphate of Ammonia per acre ..	456	·216	2,460	2,489

Here there is an advantage, which was much greater in 1920, where the transplanting was done at the normal time, than in 1921, when it was much delayed, owing to climatic reasons as previously described. Taking the two years together an advantage of about twelve per cent. is shown. Further increase in vigour by still higher manuring in the seedbed has not given any further advantage.

Vigour of seedlings is also judged by the people by the extent of tillering in the seedbed, the bed where the tillering has been most extensive being considered the more vigorous. An experiment to test this matter was made as follows. Three plots were laid out, and were planted with seedlings from the same bed sown at different seed rates to promote tillering, the bunches being twelve inches apart. In the first area one seedling which had four culms (one mother culm and three tillers) was planted per bunch; in the second, two seedlings, each with two culms (one mother culm and one tiller) were planted per bunch, and in the third, four non-tillered seedlings were put in in each bunch. The results in 1920 and 1921 may now be given :—

Seedlings planted per bunch.	Earheads per unit area.	Average yield per earhead tolas.	Yield per acre.	
			Grain.	Straw.
1920.			lbs.	lbs.
1. One plant with four culms ..	240	250	2,704	2,896
2. Two plants each with two culms ..	297	315	2,933	3,455
3. Four plants each with one culm ..	345	358	3,447	3,549
1921.				
1. One plant with four culms ..	307	267	2,010	1,950
2. Two plants each with two culms ..	332	282	2,273	2,273
3. Four plants each with one culm ..	373	240	2,208	2,039

The results show a distinct advantage with the larger number of plants even if each of them is weaker, as shown by the number of tillers produced. The average yields for the two years are in fact :—

Seedlings planted per bunch.	Average yield per acre for 1920 and 1921.	
	Grain.	Straw.
	lbs.	lbs.
1. One plant with four culms ..	2,357	2,423
2. Two plants each with two culms ..	2,603	2,864
3. Four plants each with one culm ..	2,827	2,794

These results introduce a new factor, however, as to whether, considered as productive units, the tillers are the equivalent of mother plants, and so little stress can be laid upon them, as indicating the value of vigour in the seedlings transplanted. But they *do* show that culms produced from vigorous seedlings are not necessarily more productive than culms produced from weaker plants.

Before drawing final conclusions with regard to the effect of the vigour of seedlings on the final crop yields after transplanting, we may perhaps

consider the results obtained elsewhere in Western India, on a farm scale. Two series of experiments can be presented.

1. *Experiments at Alibag.*—In this case the plots were planted with bunches each containing sixteen seedlings. In one case the seedlings were specially strong, and in the other they were of average type. The yield of grain per acre has been as follows :—

Character of seedlings.	Yield of grain per acre.				Average.
	1916.	1917.	1918.	1919.	
	lbs.	lbs.	lbs.	lbs.	lbs.
1. Strong seedlings ..	2,440	1,900	2,320	2,960	2,405
2. Ordinary seedlings ..	2,600	1,840	2,400	3,080	2,480

The difference between the two classes of seedlings is only three per cent. in favour of the weaker seedlings,—a result which is well within the margin of experimental error.

2. *Experiments at Ratnagiri.*—The experiments to be quoted was conducted in 1915, and was exactly similar to that above described, with the following results :—

Character of seedlings.	Yield of grain per acre.		Average.
	First set.	Second set.	
	lbs.	lbs.	lbs.
1. Strong seedlings ..	2,980	2,380	2,680
2. Ordinary seedlings ..	2,670	2,110	2,390

Here the difference is greater than in the last case, and amounts to about twelve per cent. in favour of the strong seedlings, and it is repeated in each of the two sets of experiments.

It would have been interesting to have also described the evidence obtained abroad on the subject under discussion, but this would lead too far. A piece of evidence given by Keatinge as a result of a visit to Java may, however, be quoted.\* He states that in Java “the seedbed is made in poor soil and given no manure, the theory being that if you grow seedlings in a manured seedbed under favourable conditions, they will do badly when put out into unmanured fields and possibly subjected to a shortage of water, but if you grow them in poor soil with very little water they will be hardy and drought resistant.” It is probable that there is nothing in the theory, but the fact, that no attempt is made to ensure the vigour of the seedlings in Java, is important.

\* G. F. Keatinge—Report of Tour, issued by the Government of Bombay on March 24th, 1914.

From all the data now considered as to the relationship of the vigour of the seedlings transplanted to the ultimate yield of rice grain, the following conclusions may be deduced :—

1. The vigour of the seedling has little direct influence on the ultimate yield of rice per acre, the chief advantage of highly vigorous seedlings being that they are better able to withstand the field water conditions after transplanting.

2. Distinctly weak seedlings, as obtained in untreated seedbeds tend to be too small to sustain the water conditions in the fields and this disadvantage may react on the plant until growth ceases.

3. Exceptionally vigorous seedlings, or seedlings raised with large quantities of manure do not show any appreciable advantage in the transplanted crop.

4. The original vigour of an ordinarily healthy seedling seems to be what determines its ultimate yielding capacity. The artificial vigour brought about by treatment of the seedbed, only produces a very small increase in ultimate productivity, which rarely exceeds ten to twelve per cent. and this by no means in all cases.

5. The production of vigorous seedlings, although they do not yield appreciably higher than those with less vigour has a great economic advantage in rice farming in the Konkan and similar regions, in that they do withstand the water conditions which prevail more successfully than the weaker ones. This is a matter of great importance in the Konkan, and largely determines (as will be later seen) the number of seedlings planted per bunch, as well as the insistence on vigour in the seedlings which is so marked among the cultivators of the Konkan.

*Effect on the yield of rice of the spacing between bunches in the transplanted field.*—A variation in the number of plants planted per unit area is possible in two ways, namely, by changing the number of seedlings planted in each bunch, keeping the spacing constant, or by altering the distance between the bunches, keeping the number of seedlings in each bunch constant. It might at the first sight be supposed that the number of ultimate ears borne per unit area might vary directly and in the same proportion as the number of plants planted. But the results of studies detailed above (page 30) indicate that this is by no means the case, for it is shown that as the amount of space allotted to each plant increases, the number of tillers per acre does not increase in anything like the same proportion. In fact as the space allotted increased from 1 to 16, the amount of tillering only increased from 1 to 5. Again it was shown (page 45) that the average yield per earhead decreases with the decrease in space given in planting. The final yields should, therefore, be highest where the product of the number of earheads per acre and the average yield per earhead give the maximum figure. The results so calculated and the actual yields obtained in the field do not differ widely, and show that the maximum produce (when six seedlings are planted per bunch) is reached when the spacing of the bunches is from nine



to twelve inches apart. The actual figures in 1920 and 1921 are as follows :—

Plot No.	Spacing of bunches.	Earheads per unit area.	Weight per earhead tolas.	Rates of calculated yield (Plot 1 = 100).	Actual yield per acre.	Rates of actual yields (Plot 1 = 100).
1920.						
1	6 inches apart ..	850	·089	100	1,900	100
2	9 inches apart ..	590	·163	127	2,075	109
3	12 inches apart ..	493	·193	126	2,417	127
4	15 inches apart ..	416	·215	118	2,422	127
5	18 inches apart ..	358	·246	117	2,027	107
6	24 inches apart ..	261	·262	90	1,712	90
1921.						
1	6 inches apart ..	959	·144	100	3,343	100
2	9 inches apart ..	631	·215	98	3,374	101
3	12 inches apart ..	573	·253	94	3,235	97
4	15 inches apart ..	439	·281	89	3,170	95
5	18 inches apart ..	361	·291	76	2,804	78
6	24 inches apart ..	250	·289	52	1,701	51

It will be seen from these figures how the calculated yield and the actual yield correspond as nearly as can be expected, and they show that wider spacing of the bunches than fifteen inches apart, means lower yield, the increase in size of earhead not making up for the smaller number of earheads per acre. It has already been shown (page 30) that spacing wider than twelve inches does not compensate by increase of tillering for the decreased number of plants per acre.

*Effect on the yield of rice of the number of seedlings per bunch.*—The number of original culms per acre and hence the area per bearing culm is determined partly by the spacing between the bunches, and partly by the number of seedlings planted per bunch. The effect of the former has just been considered, the second may now be discussed.

If we present the figures in the same way as was done in the last case we have figures for 1920 and 1921 as follows : The number of seedlings planted per bunch varied from two to twelve, and the bunches were nine inches a part in both directions.

Plot No.	Seedlings per bunch.	Earheads per unit area.	Weight of grain per earhead tolas.	Rates of calculated yield (Plot 1 = 100).	Actual yield per acre.	Rates of actual yields (Plot 1 = 100).
1920.						
1	2 Seedlings ..	122	·215	100	2,958	100
2	3 " ..	130	·214	108	3,047	103
3	4 " ..	136	·219	114	3,147	106
4	5 " ..	139	·205	109	3,066	104
5	6 " ..	142	·190	103	2,874	97
6	8 " ..	148	·151	85	2,018	68

Plot No.	Seedlings per bunch.	Ear-heads per unit area.	Weight of grain per ear head.	Rates of calculated yield (Plot 1=100).	Actual yield per acre.	Rates of actual yields (Plot 1=100).
	1921		tolas.		lbs.	
1	2 seedlings ..	167	.247	100	2,367	100
2	3 do. ..	198	.229	110	2,439	103
3	4 do. ..	214	.215	112	2,523	107
4	5 do. ..	241	.193	113	2,475	105
5	6 do. ..	265	.186	119	2,565	108
6	8 do. ..	298	.142	103	2,443	103

The correspondence between the calculated and the actual yields is perhaps as close as might be expected, and they show that there is a definite lower and higher limit to the number of seedlings, that can be planted per bunch. They show, moreover, that this varies from year to year. In 1920 when the planting was at the normal time the best results were obtained with four seedlings per bunch, in 1921 when the planting was very late, the maximum yield was obtained, with six seedlings per bunch. The effect of more than eight seedlings per bunch, which would represent the ordinary practice in the North Konkan, is not shown in these figures, but is being investigated now.

These figures show, however, that the numbers of seedlings which should be planted per bunch is a local matter. In South India, the planting of single seedlings has been widely recommended. In the North Konkan all the evidence accumulated by experiments at Alibag, and those now reported, indicate that it does not give the best results, which can be obtained when the number varies from four to six according to the season.

Another experiment may be quoted, in which the number of seedlings varied from four to twelve per bunch, the bunches being planted at twelve inches apart. In this case it is not possible to compare the figures of yield with the number of ear-heads per acre or the size of ear-heads.

Plot No.	Number of seedlings.	Yield of grain per acre.		
		1920	1921	Average of two years.
		lbs.	lbs.	lbs.
1	4 seedlings .. ..	2,528	1,647	2,037
2	5 do. .. ..	2,734	2,055	2,394
3	6 do. .. ..	2,839	2,268	2,553
4	8 do. .. ..	2,394	2,469	2,432
5	12 do. .. ..	2,763	2,582	2,672

As the bunches are planted more widely apart than in the last quoted experiment, the best number of seedlings per bunch would naturally

be higher, and it would be higher in 1921 than in 1920 for the same reason given above. As a result, under these conditions, six seedlings per bunch have given the best yield in 1920, while in 1921 the highest seems to be obtained with twelve seedlings or more.

But the study of the effect of the distance of planting of the bunches of seedlings and of the number of seedlings per bunch makes it clear that both the number of ear-heads per acre (depending on the tillering) and the size of individual ear-heads depend on the space allotted per plant. But a reference to the data given reveals the fact that an increase in the number of ear-bearing heads per acre is accompanied by a partially compensating reduction in the average size per ear-head. The maximum yield, that is to say, the point at which the curve representing the number of ear-heads per acre crosses that representing the average size per ear-head, indicates a space per plant which is not widely different from the ordinary cultivators' practices except in one respect. The number of plants per bunch in actual practice is higher than the experiments have shown to be the best, but the explanation of this has already been indicated in that the effect of the rushing of flood water has to be considered where, as in the North Konkan, the water in the fields is of this character almost throughout.

But it is clear that in this matter equal results *can* be obtained provided the difficulty mentioned can be overcome, if half the present number of seedlings (12 to 15) per bunch are used, and this means half the seed-bed space, and a very great reduction in expenditure. The actual number of seedlings to be used will vary according to conditions but a reduction in the number is a method of decreasing the cost of growing a crop of transplanted rice which is probably applicable over the greater part of the transplanted rice area of Western India.

*Effect on the Yield of Rice of the Extent of Puddling given to the field.*—The effect of the amount of cultivation in the mud (or in other words of the extent to which the puddle is reduced to an even and smooth consistency) on the number of ear-heads per acre, and on the size of the ear-head has been already shown (see pages 30 and 47). These show that additional working of the land in the puddle is likely to increase the yield, largely because of the increase in size of the ear-head. The actual yield obtained in both 1920 and 1921 corroborates this conclusion as the following figures show.

	Yield of grain per acre.			Relative yield, (Plot 1=100).
	1920	1921	Average.	
1. One ploughing in puddle ..	lbs. 2,610	lbs. 1,958	lbs. 2,284	100
2. Three do. ..	2,909	2,153	2,531	111
3. Five do. ..	2,990	2,197	2,593	114
4. Seven do. ..	3,064	2,421	2,742	120
5. Nine do. ..	3,336	2,748	3,042	133
6. Eleven do. ..	3,330	2,545	2,937	129

There is thus a steady increase in yield in both the years quoted as the amount of cultivation in the puddle is increased, up, at least, to nine ploughings. The effect may be due to many causes. It has been suggested that it increases the water holding capacity of the field. For the proper growth of the rice plant, and also for the proper ammonification of the nitrogenous organic matter contained in the soil, a constantly submerged condition of the field seems very beneficial. This is secured by a thorough puddling of the soil, while at the same time better scope for the free growth of the roots is obtained.

*Effect on the Yield of Rice of Manuring of the Crop.*—We have seen so far how each of the varying factors of cultivation influences the yield of the crop, and in what manner these factors produce their result. In general, it may be stated that those changes which lead to an increase in the size of the ear-heads usually also lead to a reduction in the number per acre, and *vice versa*; consequently an optimum condition can generally be reached where the yield is highest, but where something in the size of ear-head is sacrificed to get a larger number of ears per acre and something in the number of ears per acre is sacrificed to get bigger ear-heads. This optimum is generally achieved by methods which closely approximate to those in actual practice or recognised to be the best in practice. In some directions improvements can be indicated. A smaller number of seedlings per bunch can be used if the physical effect of the rush of flood water can be prevented, and a very considerable increase of yield can be obtained by more efficient and thorough cultivation in the puddle.

But the general result so far is to suggest that few of these changes in methods of cultivation will give a very marked improvement in yield over those given by the best methods now in vogue, and they do not indicate that in this direction the production can be very largely increased. Any large increase in size of ear-head without decreasing the number of ear-heads per acre has been very slight, and this increase seems definitely beyond the power of any change in environment,—even of manuring (see pages 47-49). A substantial increase in the number of ear-heads per acre without decreasing the size of the ear-heads seems possible only by definite increase in manuring in the field. It has been already shown to what extent tillering is encouraged by certain types of manuring, and it is evident that in this direction lies the great opportunity of increasing the yield, which is the main object of improving rice cultivation. In fact, we seem to be restricted to plant selection and breeding as a means of increasing the size of the ear-heads without reducing the number grown per acre, and very largely, to manuring as a means of increasing the number of ear-heads per acre, without reducing their size. The results obtained by manuring in achieving this end may now be considered.

The first experiment quoted was done in 1919, when four seedlings were planted per bunch, and the bunches spaced eighteen inches in both directions.

1919		Number of ear-heads per acre.	*Average yield per ear-head. Tolas	Yield per acre.
Manurial treatment given per acre.				
1.	4,000 lbs. of green leaf, 40 lbs. Nitrogen †, 280 lbs. Superphosphate ..	5,54,316	·260	Grain lbs. 3,013
2.	Do. 45 lbs. Nitrogen, 315 lbs. Superphosphate ..	5,75,789	·259	2,913
3.	Do. 55 lbs. Nitrogen, 380 lbs. Superphosphate ..	6,09,840	·240	2,875
4.	Do. 60 lbs. Nitrogen, 420 lbs. Superphosphate ..	6,15,054	·215	2,982
5.	Do. 65 lbs. Nitrogen, 455 lbs. Superphosphate ..	6,82,235	·253	3,489
6.	Do. 75 lbs. Nitrogen, 525 lbs. Superphosphate ..	7,01,254	·248	3,681
7.	Do. 80 lbs. Nitrogen, 560 lbs. Superphosphate ..	6,94,505	·277	3,865
8.	Do. No Manure, but planted according to local method ..	5,27,653	·212	2,649

It will be seen from this statement that the number of ear-heads per acre rises steadily with the increased dose of manure giving seven lakhs of ear-heads per acre as the maximum, while the average yield per ear-head varies within a very slight range. The final results, therefore, have increased with the addition of more manure.

The distance of eighteen inches both ways given in transplanting in 1919 was found to be rather too much and in 1920 it was reduced to fifteen inches. The results of 1920 are recorded below :—

Plot No.	Manurial treatment per acre.	Number of ear-heads per acre.	*Average yield per ear-head. Tolas.	Yield per acre.	
				Grain lbs.	Straw lbs.
1	No manure (average of three plots).	3,73,465	·317	3,064	2,837
2	60 lbs. Nitrogen, 600 lbs. Superphosphate ..	5,23,285	·248	3,418	4,150
3	65 lbs. Nitrogen, 650 lbs. Superphosphate ..	5,26,137	·274	3,676	3,827
4	70 lbs. Nitrogen, 700 lbs. Superphosphate ..	5,16,914	·292	3,721	3,000
5	95 lbs. Nitrogen, 950 lbs. Superphosphate ..	5,49,308	·244	3,704	3,850
6	100 lbs. Nitrogen, 1,000 lbs. Superphosphate ..	5,32,054	·259	3,627	3,900

In the same year in another field, lower quantities of nitrogen and phosphoric acid were tried. But as the strain of seed used for it was different, the yields cannot be compared with the previous series. The

\* Estimated from 1,000 sample earheads.

† In the form of Sulphate of Ammonia.

results are recorded below. The bunches contained few seedlings each and were twelve inches apart.

Plot No.	Manure per acre.	Number of ear-heads per acre.	Average yield per acre ear-head in tolas.	Yield per acre.	
				Grain.	Straw.
1	No manure (average of two plots) ..	427,700	·25	lbs. 2,978	lbs. 3,250
2	20 lbs. Nitrogen (1), 200 lbs. Super-phosphate ..	468,900	·25	3,203	3,800
3	30 lbs. Nitrogen (1), 300 lbs. Super-phosphate ..	482,000	·23	3,395	4,000
4	40 lbs. Nitrogen (1), 400 lbs. Super-phosphate ..	569,800	·22	3,508	4,050

(1) In the form of Sulphate of Ammonia.

Here the number of ear-heads is increased by manuring, the average yield per ear-head is slightly decreased. The final yields increase with the increase of manure.

In both these years it was found that sufficient water could not be impounded in the manurial plots on account of the low earthen bunds normally employed. The bunds of all the plots were, therefore, increased in height to twelve inches and were pitched with stone to prevent the washing down of the earth. This proved very effective in holding sufficient water.

In 1921 sufficient seed of the same strain was available for all experiments and hence the results in the duplicates are strictly comparable. The distance of fifteen inches given in the previous year in one series was also found to be too great and hence in 1921 it was reduced to twelve inches both ways. The results of the experiment are given below. :-

Plot No.	Manurial treatment per acre.	Number of ear-heads.	Average yield per ear-head. Tolas.	Yield per acre.	
				Grain.	Straw.
1	No manure (average of three plots) ..	419,100	·208	lbs. 2,161	lbs. 1,639
2	5 lbs. Nitrogen, 10 lbs. Phosphoric acid ..	454,700	·185	2,134	1,748
3	10 lbs. Nitrogen, 20 lbs. Phosphoric acid ..	475,000	·190	2,257	1,907
4	15 lbs. Nitrogen, 30 lbs. Phosphoric acid ..	491,700	·197	2,407	2,052
5	20 lbs. Nitrogen, 40 lbs. Phosphoric acid ..	509,800	·218	2,747	2,268
6	25 lbs. Nitrogen, 50 lbs. Phosphoric acid ..	548,200	·214	2,896	2,553
7	30 lbs. Nitrogen, 60 lbs. Phosphoric acid ..	580,300	·216	3,102	2,831
8	60 lbs. Nitrogen, 120 lbs. Phosphoric acid ..	703,500	·223	3,881	4,089
9	80 lbs. Nitrogen, 160 lbs. Phosphoric acid ..	796,000	·197	3,881	4,216
10	100 lbs. Nitrogen, 200 lbs. Phosphoric acid ..	836,000	·201	4,079	4,600

*Duplicate series.*

Manurial treatment per acre.	Number of ear-heads per acre.	Average yield per ear-head. Tolas.	Yield per acre.	
			Grain.	Straw.
1 No manure (average of two plots)	404,700	·217	lbs. 2,172	lbs. 1,980
5 lbs. Nitrogen, 10 lbs. Phosphoric acid	428,800	·239	2,542	2,424
10 lbs. Nitrogen, 20 lbs. Phosphoric acid	435,600	·234	2,530	2,367
15 lbs. Nitrogen, 30 lbs. Phosphoric acid	491,000	·241	2,929	2,811
25 lbs. Nitrogen, 50 lbs. Phosphoric acid	504,300	·243	3,020	3,075
30 lbs. Nitrogen, 60 lbs. Phosphoric acid	574,700	·230	3,229	3,588

*Average of two series.*

Manurial treatment per acre.	Number of ear-heads per acre.	Average yield per ear-head in tolas.	Yield per acre.	
			Grain.	Straw.
No manure	411,900	·212	lbs. 2,166	lbs. 1,809
5 lbs. Nitrogen, 10 lbs. Phosphoric acid	441,700	·212	2,338	2,086
10 lbs. Nitrogen, 20 lbs. Phosphoric acid	455,300	·212	2,323	2,137
15 lbs. Nitrogen, 30 lbs. Phosphoric acid	488,400	·218	2,642	2,380
20 lbs. Nitrogen, 40 lbs. Phosphoric acid	500,400	·229	2,838	2,540
25 lbs. Nitrogen, 50 lbs. Phosphoric acid	526,200	·228	2,958	2,814
30 lbs. Nitrogen, 60 lbs. Phosphoric acid	577,500	·223	3,165	3,210

The co-efficient of increase in 1921 for every pound of nitrogen plus two pounds of phosphoric acid comes to 5,000 ear-heads, equal to thirty pounds of grain and forty pounds of straw per acre.

By increasing the quantity of manure up to 100 lbs. nitrogen plus 1,000 lbs. of superphosphate the ear-heads and the yield are increased further. The rate of increase in yield of grain, however, beyond 60 lbs. Nitrogen plus 120 lbs. phosphoric acid is reduced. The ear-heads nevertheless show the same rate of increase, but the average yield per ear-head begins to fall suggesting that the maximum number of ear-bearing culms that can be raised per acre cannot be increased under the Karjat conditions beyond seven lakhs without causing a decrease in the average yield per ear-head.

The results of the three years studied together distinctly show that manuring up to a certain amount increases the number of ear-heads per acre without decreasing the average yield per ear-head. The final yields, therefore, tend to increase.

Whether these increases in yield can be obtained economically in practice will depend on the right form of the manure applied at proper time and it would form the subject of future work and record. But the study of the food requirements of the rice crop with a view to ascertain the most economic method of application has only been begun.

In carrying this out, however, the first step must be to determine the relative importance of the several elements of plant food used singly or in combination. This step has been undertaken in pot cultures but as the work has been started only very recently, it would be premature to quote the full results and draw conclusions, from one or two years' experiments.

Apart from such a detailed and elaborate study of the plant food requirements of rice which has been commenced now, some experiments to determine the best proportion of phosphoric acid to nitrogen in rice manuring have, however, been conducted for two years during 1920 and 1921. The figures of yield have been produced below:—

Treatment per acre, planting 4 culms 12" apart.	Yields per acre.			
	1920.		1921.	
	Grain.	Straw.	Grain.	Straw.
Sulphate of Ammonia 200 lbs., Super- phosphate 200 lbs. .. ..	lbs. 2,873 (1)	lbs. 3,527	lbs. 2,568 (1)	lbs. 2,449
Sulphate of Ammonia 200 lbs., Super- phosphate 400 lbs. .. ..	3,149	3,928	3,042	3,160
Sulphate of Ammonia 200 lbs., Super- phosphate 600 lbs. .. ..	3,453	4,500	3,290	3,351
Sulphate of Ammonia 200 lbs., Super- phosphate 800 lbs. .. ..	3,228	3,884	3,427	3,515
Sulphate of Ammonia 200 lbs., Super- phosphate 1,000 lbs. .. ..	3,097	3,502	3,360	3,450
No manure .. ..	2,840	3,500	2,233	2,057

(1) This plot gives rather less than should be the case, as it was not, as well situated as the others.

The strains of rice used in the two years were different. The factor of climate seems to have influenced the results. But it is clear from the yields of both the years that beyond 600 to 800 lbs. of Superphosphate combined with 200 lbs. of Sulphate of Ammonia the yield begins to fall. The increase brought about by the addition of increased amounts of Superphosphate are proportionately very low. This may partly be ascribed to the Karjat soils being sufficiently rich in the available



phosphoric acid as was indicated in pot and field trials in 1921 when superphosphate was applied to the crop singly at the rate of 266 lbs. without much effect. The results of the trials of superphosphate are recorded below. The plants were in bunches of four culms each, twelve inches apart.

Treatment per acre.	Yield per acre.	
	Grain.	Straw.
Sulphate of Ammonia 200 lbs.	lbs. 2,873	lbs. 2,609
Superphosphate 266 lbs.	2,079	1,694
No manure	2,206	1,841

A similar experiment was carried out in pot culture the average figures from three pots being given below in each case :—

Treatment per acre.	Yield per pot. Grain in grams.
Sulphate of Ammonia 200 lbs. .. ..	37·6
Superphosphate 266 lbs. .. ..	28·7
No manure .. ..	25·8

That phosphoric acid was not an emphatic need of these soils is shown by the following experiments where phosphoric acid was applied in combination with nitrogen in pot cultures in the proportion of one of nitrogen to one of phosphoric acid, hardly any increase has been obtained as will be seen from the following :—

Treatment per acre.	Yield of grain per pot in grams. 1921.
Sulphate of Ammonia (40 lbs. Nitrogen) .. ..	37·6
Sulphate of Ammonia Superphosphate (40 lbs. Nitrogen) (=40 lbs. Phosphoric acid) .. ..	37·8
No manure .. ..	25·8

## CHAPTER VII.

### SUMMARY OF CONCLUSIONS.

The present stage of our physiological study of the rice plant, with a view ultimately to increase the yield per acre enables us to draw a number of fairly definite conclusions which may now be summarised. Details of the experiments on which these conclusions are based will be found in previous chapters. Some of them are probably of general application, while others will apply only under the conditions of the North Konkan. These conclusions are as follows :—

(1) Seeds should not be sown deeper than two inches. Surface sowing should also be avoided.

(2) The best seed-rate seems to be that which would produce neither thin lanky seedlings on account of shortage of space or tillered seedlings, due to extra space in the seed-bed. A seed rate of seven to eight pounds per guntha of seed-bed (1/40 acre) brings about the desired results.

(3) Seedlings should be transplanted from about a fortnight prior to the formation of a node above ground to just a short time before it is actually formed. This stage is arrived at at Karjat in a treated seed bed in about twenty-four to forty days after sowing.

(4) The operation of transplanting does not seem to result in any physiological advantage to the plant capable of resulting in an increase in the yield. That tillering is encouraged by the stimulus of root prunning in the system of transplanting does not find confirmation in these experiments. Transplanting seems to be more an expedient than a requisite condition of cultivating rice.

(5) On transplanting, the old root system of the plant becomes unserviceable and the plant has to develop new roots for its use.

(6) Tillering is a factor of great economic value in rice cultivation and it is largely dependent on space and plant food. Other factors of cultivation such as the age and vigour of seedlings at transplanting, the number of plants per bunch affect tillering to a limited extent. Too much tillering is again detrimental as it results in sterility of the late born tillers and uneven maturity of the whole crop. Heavy tillering is generally accompanied by a larger percentage of loss of later tillers and this occurs whatever the treatment is. The girth of the stem near the ground level is definitely and highly correlated to the length of the ear-head. The bigger the girth the longer is the ear-head.

(7) In a plant, the mother ear-head is generally the biggest under the usual system of planting. Certain circumstantial advantages, however, such as extra spacing, etc., tend to increase the size of the ear-heads of tillers over that of the mother culm.

Such are the results of our study of the effect of varying environments on the plant itself. The following summary indicates how this effect can be connected with the effort to increase the yield of the crop per acre.

(1) To obtain the highest yield the seedlings should be transplanted upto but not later than the period of node formation above ground in the seed-bed.

(2) The vigour of seedlings does not seem to influence the yield in any way except in so far as it enables the plant to overcome adverse environmental conditions during and after transplanting. Again tillered seedlings seem in no way to improve the yield.

(3) A thorough puddling of the land is associated with high yield.

(4) According to the season and soil conditions in the North Konkan from four to six seedlings per bunch spaced nine inches both ways or six to eight seedlings planted twelve inches apart both ways seem to be the best practice.

(5) The two factors of yield namely the number of ear-heads per unit area and the average yield per earhead are inversely related to each other and hence any attempt to bring about an increase in one of them is counteracted by a reverse process of proportionate decrease in the other except that of manuring in which the number of ear-heads per unit area increases without decreasing the average yield per ear-head.

(6) Thus out of the several aspects in the life history of the rice plants and their behaviour under different conditions of environment so far studied, manuring chiefly with nitrogenous fertilisers seems to be the only factor by which rice can be made to yield substantially more per unit area.

#### APPENDIX A.

*Composition of the Rice Seedlings 16 to 64 days old referred to on page 55.*

Age of seedlings days.	Moisture.	Ether Extract.	Albuminoids.	Dig. Carbohydrates.	Woody Fibre.	Ash.	Cellulose.	Nitrogen.	Sand.	Potash.	Phosphoric acid.	Lime.	Iron and aluminium.
16	85.5	4.17	35.50	22.02	15.40	22.91	14.83	5.68	12.36	8.64	1.65	0.58	2.31
24	87.20	4.74	25.43	30.98	17.03	21.82	14.18	4.07	13.15	8.71	1.49	0.57	1.78
32	84.90	4.96	22.87	31.32	18.28	22.57	17.34	3.18	12.95	3.95	0.94	0.58	1.30
40	84.70	1.84	17.87	31.31	23.05	25.93	21.36	2.86	16.94	4.62	1.04	0.57	1.79
48	82.0	1.89	11.06	38.96	24.99	23.10	22.10	1.77	12.60	3.76	0.71	0.88	1.54
56	81.4	2.33	11.25	40.74	23.88	21.80	20.26	1.80	9.39	3.49	0.73	0.58	1.05
64	76.4	1.87	7.87	50.38	23.14	16.74	20.59	1.26	9.72	2.69	0.45	0.86	1.05
			Seed rate	240 lbs. per acre	of seed bed (1920).								
16	87.0	4.47	31.25	24.92	17.45	21.91	16.62	5.00	11.91	4.21	1.67	0.58	1.81
24	85.70	4.22	13.07	42.29	18.85	21.57	17.97	2.09	12.92	4.19	1.71	0.58	2.06
32	84.7	4.67	14.47	38.77	21.00	20.89	19.42	2.30	13.02	4.12	0.82	0.44	1.05
40	84.3	2.16	10.43	39.94	22.45	25.02	19.36	1.67	15.86	4.44	0.78	0.43	1.28
48	85.	1.97	10.12	42.77	24.34	20.80	22.72	1.62	11.47	3.47	0.90	0.56	1.04
56	85.	2.36	9.75	44.59	24.04	19.26	21.76	1.56	11.47	2.69	0.63	0.56	1.05
64	71.8.	2.25	9.95	51.64	23.47	16.69	20.0	0.95	9.24	2.59	0.54	0.43	1.05

## APPENDIX B.

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**REPORT**  
ON THE  
**AGRICULTURAL STATIONS**  
IN THE  
**CENTRAL CIRCLE, CAWNPORE**  
FOR THE YEAR 1922-23.

J. 25236;g 3N:1



ALLAHABAD.

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FROM

DR. H. M. LEAKE, SC.D., F.L.S., M.L.C.,  
DIRECTOR OF AGRICULTURE, UNITED PROVINCES,

TO

THE SECRETARY TO GOVERNMENT, UNITED PROVINCES,  
AGRICULTURE DEPARTMENT, ALLAHABAD.

*Dated Lucknow, the 18th July, 1923.*

SIR,

I HAVE the honour to submit the report on the agricultural stations in the Central Circle for the year ending 30th June, 1923. The report has been drawn by Mr. Low, Deputy Director of Agriculture, Central Circle, Cawnpore.

I have the honour to be,

SIR,

Your most obedient servant,

H. M. LEAKE,

*Director of Agriculture, United Provinces.*

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### GLOSSARY OF VERNACULAR TERMS USED.

Kapas ...	...	...	=	Seed cotton.
Bhusa ...	...	...	=	Chopped and crushed straw.
Maund ...	...	...	=	82·3 lbs.
Juar ...	...	...	=	<i>Sorghum vulgare</i> .
Bajra ...	...	...	=	<i>Pennisetium typhoides</i> .
Guar ...	...	...	=	<i>Cyamopsis psoraloides</i> .
Gram (vernacular chana)	...	...	=	<i>Cicer arietinum</i> .
Mahua ...	...	...	=	<i>Bassia latifolia</i> .
Kesari ...	...	...	=	<i>Lathyrus sativus</i> .
Berseem...	...	...	=	Egyptian clover ( <i>Trifolium alexandrinum</i> ).
Sanai (Sann bemp) ...	...	...	=	( <i>Crotolaria Juncea</i> ).
Mung ...	...	...	=	<i>Phaseolus mungo</i> .
Urd ...	...	...	=	<i>Phaseolus radiatus</i> .
Arhar ...	...	...	=	Pigeon pea ( <i>Cajanus indicus</i> ).
Palewa ...	...	...	=	Irrigation (flooding) followed by ploughing prior to sowing.
Rabi ...	...	...	=	Winter (crops).
Kharif ...	...	...	=	Summer (crops).

## Report of the Agricultural Stations of the Central Circle for the year 1922-23.

The Central Circle consists of the following districts and has the following Government Farms :—

District.	Farm.	Area in acres.
Cawnpore	Government Experimental Station	57·60
	Kalianpur Seed Farm	260·51
Allahabad		...
Fatehpur		...
Jhansi		...
Hamirpur	Bela Tal Farm	30·62
Banda	Attara Farm	171·46
Jalaun	Orai Farm. (Now closed under orders of Government).	87·00
Unao		...
Sitapur		...
Kheri		...
Hardoi	Hardoi Farm	40·00
Etawah	Etawah Farm	51·35
Mainpuri	Mainpuri Farm	52·81
Farrukhabad		...

The detailed results obtained on these farms during the year follow :—  
For financial results the Administration Report of the department should be consulted.

### 1.—CAWNPORE EXPERIMENT STATION.

#### CHAPTER I.

##### (a) Situation, area and soils.

The Cawnpore experiment station includes the experimental farm proper and the seed farm at Kalianpur. On the latter farm certain large scale experiments are carried out which the restricted size of the experimental farm will not permit of.

The experiment station is situated close to Rawatpur on the Cawnpore-Achnera Railway and about four and five miles respectively from the East Indian and Oudh and Rohilkhand Railway stations.

The whole area is irrigable from a distributary of the Ganges canal and consists of about 57·6 acres, of which 34·6 acres are under cultivation: the rest being occupied by roads, watercourses, tanks, farm buildings and staff quarters.

The soil may be accepted as a fair sample of the alluvial loam which occurs over a large portion of the Ganges-Jumna *doab*.

Chemical analysis and practical experience concur in showing that there is no abnormal deficiency of lime or other plant foods.

The cultivated area of the Cawnpore seed farm (Kalianpur) during the year under report was about 216 acres. The terracing, draining and levelling of this area has been completed and it is all now in good order,

although it will yet be some years before certain fields will be uniform. The area of the farm has now been increased to about 260 acres gross, which will give a cultivated area of approximately 240 when the new land has been levelled and properly laid out.

#### (b) Wheat.

The wheat standard series plots which have been unmanured since 1913 yielded an average of 678 lbs. grain and 1,266 lbs. straw per acre. The previous treatment of these plots can be seen by consulting back reports of the Cawnpore Experimental Farm.

#### *Comparison of wheat yield after leguminous fodder crop and after summer fallow.*

For the fifth year this experiment has shown that a larger wheat yield is obtained after a summer fallow than after a leguminous fodder crop and it will now be discontinued.

Crop.	Average yield per acre.		Remarks.
	Grain.	Straw.	
Wheat after <i>guar</i> ...	716	1,376	The plots were sown with Pusa no. 12 wheat on 27th October, 1922, at 100 lbs. seed per acre. Both plots unmanured. The fallow plot received hot weather ploughing and cultivation.
Wheat after fallow ...	988	1,953	

#### *Comparison of varieties of Pusa wheats.*

Six of the new Pusa wheats of the 50 series were again under trial but the crop owing to bad germination and damage by rats in the later stages of growth, was not sufficiently level for the figures obtained to be reliable for comparison. It would appear though from trials in previous years both at Cawnpore and Hardoi that Pusa 54 and Pusa 52 show the most promise for this circle and these two varieties will be sown on a larger scale in the next *rabi* season.

#### *Trials with other varieties of wheat.*

A variety of awned desi wheat from Sherpur, district Unao, was tried with Pusa 12 as a control. Its yield was slightly better than Pusa 12 but it was later in ripening and showed a marked tendency to be attacked by rust. In the opinion of the Imperial Economic Botanist it is not likely to be worth extended propagation for seed distribution purposes.

Two varieties B.13 and B.30 obtained from Bhopal were also under trial. B.30 lodged badly resulting in a much reduced yield and both varieties were severely attacked by rust and are therefore not suitable for adoption.

#### *Seed production.*

At the Kalianpur Farm 66.7 acres of Pusa 12 wheat and 11.2 acres Pusa 4 wheat were grown yielding an average of 1,710 lbs. grain and 3,441 lbs. straw and 1,788 lbs. grain and 3,625 lbs. straw respectively. This is an average of about 22 maunds per acre over the whole farm and is practically the same as that of the previous season.

## (c) Gram.

(a) Sowing distance experiment with varying seed rates with local gram,

Average yield in lbs. per acre.

Distance between rows.	Seed rate in lbs. per acre.	Grain.	Straw.	Remarks.
12"	80	3,130	3,930	All plots sown with local gram at seed rate and distance noted. Previous crop, wheat unmanured.
18"	60	3,080	4,245	
24"	55	2,930	3,995	

This experiment has given no conclusive results. In previous years it has been found that the best results are obtained by sowing at a distance of 18" between rows.

*Variety test of gram.*

Average yield in lbs. per acre.

Variety.	Grain.	Straw.	Remarks.
Pusa 6 ...	2,277	4,026	All plots were triplicated. Grams sown on 18th October, 1922, at 80 lbs. per acre, harvested on 26th March, 1923. Unmanured, unirrigated, previous crop, jua unmanured.
Pusa 25 ...	2,549	3,909	
Malida ...	1,749	3,706	
Local ...	2,389	4,549	

As in previous years Pusa no. 25 has given the best yield.

*(c) Seed rate experiment.*

Yield in lbs. per acre.

Local gram sown at seeds per acre.	Average yields of triplicate plots.		Remarks.
	Grain.	Straw.	
20 ... ..	1,477	3,972	Sown on 18th October, 1922, behind country plough. No irrigation. Previous crop wheat unmanured. Harvested on 22nd March, 1923.
25 ... ..	1,485	3,282	
30 ... ..	1,570	3,072	
35 ... ..	1,574	3,527	
40 ... ..	1,551	3,236	

The figures obtained in this trial bear out those obtained in 1920-21 namely that a seed rate of 30—35 seeds per acre produces the best yield.

*Seed production.*

About six acres of Pusa no. 25 gram grown for seed production on the Cawnpore farm yielded 2,147 lbs. or 26 maunds per acre of grain, one plot of 2/7 acre giving the exceptional yield of 44.4 maunds per acre.

At the Kalianpur farm 44.27 acres of various varieties of gram yielded an average of 1,673.5 lbs. grain and 1,752 lbs. straw per acre. This is an increase over the yields obtained in the previous season.

(d) Sugarcane.

A trial to ascertain the effect of early and late sowing on the outturn of gur was undertaken with the following results. The cane selected for trial was A-42—an early ripening thin variety—and it was sown in plots 5/22 acre in area.

Date of sowing.	Month of crushing.	Outturn in lbs. per acre. Stripped cane.	Percentages.			Remarks.
			Juice.	Gur.	Gur.	
			Cane.	Juice.	Cane.	
20th February, 1922.	November...	41,490	63.1	18.5	11.7	All plots were manured with poppy cake at 10 maunds per acre. Previous crop, early Arhar, unmanured. The early sown plot received 2 additional irrigations.
Ditto ...	January ...		64.4	19.2	12.4	
24th March, 1922.	November...		61.8	18.0	11.0	
Ditto ...	January ...	37,610	67.0	19.4	13.0	

It will be seen that the early sown plot produced an appreciably heavier yield of cane while there is little difference in the gur and juice percentages.

*Manurial experiment.*

With a view to ascertain the optimum quantity of manure necessary for the growth of medium canes at Cawnpore a trial was carried out with S. 39 and S. 43 varieties on plots manured at the rate of 12½, 20, 25 and 40 maunds of castor cake per acre supplemented by green manure. In all cases the canes grew very tall and lodged badly owing to heavy rains and high wind. The results are therefore not reliable but from the figures obtained it would appear that 20—25 maunds castor cake per acre gives the best results. The percentages of juice to cane, gur to juice, and gur to cane ascertained by experimental crushings are practically the same in all cases.

At the Kalianpur farm 3.8 acres *paunda* cane was grown and 2 acres of *ukh*. This was sold in the market for seed.

(e) Cotton.

*Cotton for seed production.*

The following yields in lbs. per acre of *-kaps* was obtained on the Government Seed Farm, Kalianpur.

Yields in lbs. per acre.

Variety.	Area in acre.	Date of sowing.	Irrigations.	Seed rate.	Previous crop.	Yield in lbs. per acre.	Remarks.	
J. N. 1	2.12	5th June, 1922	2 flushings	15 lb. per acre	Wheat manured	594	Average yields 439 lbs. per acre.	
Ditto	2.22	7th Ditto	Ditto	Ditto	Ditto	376		
Ditto	3.51	7th Ditto	Ditto	Ditto	Gram unmanured	439		
Ditto	1.55	8th Ditto	Ditto	Ditto	Wheat manured	290		
Ditto	1.46	7th Ditto	Ditto	Ditto	Ditto	325		
Ditto	2.05	18th Ditto	Ditto	Ditto	Ditto	339		
Ditto	1.96	18th Ditto	Ditto	Ditto	Ditto	518		
Ditto	3.13	11th Ditto	Ditto	Ditto	Ditto	535		
Ditto	2.10	8th Ditto	Ditto	Ditto	Ditto	582		
Ditto	.85	28th May, 1922	Ditto and 1 irrigation	Ditto	Ditto	439		
Ditto	1.66	29th Ditto	1 flushing and 1 irrigation	Ditto	Gram unmanured	341		
Ditto	2.35	29th Ditto	2 flushings	Ditto	Wheat manured	422		
Ditto	1.95	1st June, 1922	Ditto and 1 irrigation	Ditto	Ditto	340		
Ditto	.87	1st Ditto	Ditto	14 Ditto	Ditto	240		
Ditto	2.40	30th May, 1922	Ditto and 1 irrigation	15 Ditto	Ditto	468		
Ditto	1.95	12th June, 1922	Ditto ditto	Ditto	Gram unmanured	483		
Ditto	.619	12th Ditto	Ditto ditto	Ditto	Ditto	623		
Ditto	4.62	19th Ditto	Ditto	Ditto	Wheat manured	458		
Ditto	1.20	12th Ditto	Ditto	Ditto	Ditto	514		
Ditto	3.94	13th Ditto	Ditto	Ditto	Ditto	464		
K. 23	1.23	24th May, 1922	1 Ditto and irrigation	Ditto	Gram unmanured	547		467 lbs. per acre.
Ditto	1.59	25th Ditto	2 Ditto	14 Ditto	Wheat manured	562		
Ditto	.995	26th Ditto	Ditto	Ditto	Do. unmanured	274		
C. A. 9.	1.35	20th Ditto	1 Ditto and 1 irrigation	15 Ditto	Gram unmanured	309		339 lbs. per acre.
Ditto	1.31	20th Ditto	2 Ditto	Ditto	Ditto	208		
Ditto	2.12	28rd Ditto	Ditto	Ditto	Wheat manured	411		
Ditto	2.23	16th Ditto	1 Ditto and 1 irrigation	Ditto	Gram unmanured	427		
Ditto	2.07	21st Ditto	2 Ditto and 2 irrigations	14 Ditto	Ditto	407		
Ditto	1.07	21st Ditto	Ditto ditto	Ditto	Ditto	441		
Ditto	1.00	27th Ditto	Ditto ditto	Ditto	Wheat unmanured	176		

( 3 )

During the previous year the average yields at the seed farm were J. N. 1, 480 lbs. and C. A. 9, 631 lbs. per acre. Small areas of C. A. 9 and J. N. 1 cotton grown on the Cawnpore Experimental Farm yielded respectively 364 lbs. kapas, ginning percentage 33.6 per cent. and 455 lbs. kapas, ginning percentage 36.1 per cent. per acre.

On both the Cawnpore and Kalianpur Farms the yields are not up to average owing to the very heavy rainfall.

*Comparison of J. N. 1 and K. 22 cotton under cultivators' conditions.*

Two uniform plots 58 acre in area were sown with the above varieties of cotton. Sowing was carried out behind country plough in lines 2' apart on each plot on 4th July 1922 at seed rate of 12 lbs. per acre. All operations of cultivation and sowing were performed after rain had fallen and no *palewa* was given. The previous crop was wheat green-manured with *sa ai*. K. 22 variety received 5 pickings, J. N. 1 received 7 pickings. The resulting yields were K. 22, 203 lbs. kapas per acre and J. N. 1, 326 lbs. kapas per acre.

(f) Maize.

Jaunpur maize grown for seed production yielded as under :—

*Yield in lbs. per acre.*

Variety.	Area.	Grain.	Remarks.
Jaunpur	$\frac{2}{5}$ acres	2,058	Manured with castor cake at 10 mannds per acre. Seed sown in rows 2' apart at 30 lbs. per acre. Previous crop groundnut.
Jaunpur	48 acres	1,319	This plot suffered from waterlogging. Sown in rows 2' apart at 30 lbs. per acre. Unmanured, previous crop potato manured with castor cake.

The above outturns are satisfactory.

(g) Arhar.

8.05 acres of Unaq early arhar grown for seed production at the Kalianpur Farm yielded an average of 1073 lbs. grain per acre and a small area at the Cawnpore Farm yielded 1,033 lbs. grain per acre.

(h) Bajra.

Small plots of awned and Sitapur-Rohtak bajra grown for comparison yielded as follows :—

*Yield in lbs. per acre.*

Variety.	Grain.	Remarks.
Awned	637	Both plots sown in rows 18' apart at 14 lbs. per acre. Previous crop wheat unmanured.
Sitapur-Rohtak	639	Damaged by birds.



These results bear out those obtained in a similar trial carried out the previous year that the Sitapur-Rohtak variety is not superior in yield and is more liable to damage by birds.

## (i) Juar.

Cawnpore Dodania and Ghasua Juar grown for comparison yielded as under :—

*Outturn in lbs. per acre.*

Variety.	Grain.	Remarks.
Cawnpore Dodania	1,416	Sown in rows with Cole planter 18" apart at 6 lbs. per acre.
Ghasua	1,220	Previous crop, Barseem unmeasured.

The two varieties have now had a continued trial over a period of several years and have demonstrated that they are consistent yielders with but little to choose between them.

## (j) Sanai.

A small area of this crop was grown for seed supply on the Cawnpore Farm the yield was 1,817 lbs. seed per acre and at Kalianpur Farm 1,217 lbs. per acre.

## (k) Green Fodder.

The following green fodder was grown at the Kalianpur Farm for bullock feed :—

Juar : 2.46 acres yielded 10,829 lbs. green fodder per acre.

Juar and guar : 7.734 acres yielded 30,228 lbs. green fodder per acre.

Impey and guar : 3.93 acres yielded 31,928 lbs. green fodder per acre.

.71 acre guar grown for seed production yielded 1,039 lbs. seed per acre.

Oats 2.2 acres yielded 18,840 lbs. green fodder per acre.

Peas 1.3 acre yielded 2,446 lbs. green fodder per acre.

Lucerne 2.39 acres yielded 18,585 lbs. green fodder per acre.

## CHAPTER II.

## MISCELLANEOUS EXPERIMENTS.

## I.—Cultivation experiments.

An experiment was commenced to ascertain what increase in yield, if any, was obtained in the wheat crop by deep ploughing with inversion in comparison with the ordinary type of ploughing with the desi plough. For this purpose 4 plots duplicated one-fifth acre each in area were selected and treated as under. The results obtained are given below. They are not very conclusive but show an advantage in favour of inverted ploughing. This experiment will be repeated.

## Yield in lbs. per acre.

Treatment.	Grain.	Straw.	Remarks.
Deep ploughing with inversion iron plough.	1,837	2,960	All plots sown with Pusa 12 at 100 lbs. per acre on 28th October, 1922. 4 deep ploughings with Punjab plough 6-8" deep.
Deep ploughing without inversion country plough.	1,187	2,290	4 deep ploughings with Egyptian plough 6-8" deep.
Shallow ploughing with inversion iron plough.	1,430	2,810	4 shallow ploughings with Punjab plough 4-5" deep.
Shallow ploughing without inversion country plough.	1,100	3,067	4 shallow ploughings with Egyptian plough 4-5" deep.

N.B.—The seed bed for all plots was prepared in the usual way with country plough.

An experiment was also commenced to ascertain if any difference in the yield of the wheat crop was obtained when in the course of the preparation of the seed bed after the use of the *pata* a light brush harrow was run over the surface of the field to break capillarity. No very distinctive difference was noticeable but the previous crop on the plot where the experiment was carried out was heavily manured sugarcane. The experiment will be repeated again on poorer quality land more comparable with the conditions obtaining on an ordinary cultivator's field.

## Average yield of plots in lbs. per acre.

Treatment.	Grain.	Straw.	Remarks.
<i>Pata</i> only ... ..	1,893	3,270	All plots sown with Pusa 4 wheat at 100 lbs. per acre on 26th October, 1922.
<i>Pata</i> and Harrow ... ..	1,989	3,165	All plots <i>pataed</i> 6 times and those that received <i>pata</i> and harrow were run over with a light lever harrow.

## II.—Comparison of the relative manurial effects of various cakes on potatoes (Phulwa).

This is a continuation of the experiment carried out last year :—

Manure applied to give 100 lbs. nitrogen per acre.	Average yield of tubers in lbs. per acre when manure was applied direct to potato crop.	Average yield of tubers in lbs. per acre when manure was applied to previous crop of maize.
Mahwa cake ... ..	10,860	8,072
Poppy cake ... ..	14,290	7,672
Castor cake ... ..	13,590	6,687
No manure ... ..	7,275	4,886

In this trial poppy cake has given the best results when applied direct to the crop and mahwa cake would appear to have the greatest residual effect.

## APPENDIX A.

*Character of the season.*

The rainfall at Cawnpore Farm during the year amounted to 42.47 inches. The monsoon set in at the end of June, and the kharif sowings were completed in good time. With the exception of a break in the last half of the first fortnight of August the rains were continuous until they ceased in the third week of September. This told heavily on the growth and produce of kharif crops, particularly cotton and arhar. Also it did not allow weeding of kharif crops and the necessary cultivation of fallow plots for rabi. The rabi was sown without Palewa and some very good yields were obtained from gram. The winter rains amounted to 1.15 inches, but as they were received in five different small falls they induced and encouraged rust on wheat rather than being of much benefit to the crop. The wheat outturns were consequently not up to expectation. All other conditions of the season were normal.

## APPENDIX B.

Statement showing the daily rainfall at the Government Experimental Farm, Cawnpore, for the year 1922-23.

Month.	Date.	Rain-fall in inches.	Fort-nightly total,	Month.	Date.	Rain-fall in inches.	Fort-nightly total.
June, 1922 ...	2nd	.74	.74	August, 1922 ...	18th	.25	
	16th	.02			19th	.85	
	23rd	.04			20th	.05	
	27th	.90	.96		21st	.88	
July, 1922 ...	1st	.62			22nd	.86	
	2nd	.06			24th	.05	
	3rd	.97			25th	2.91	
	5th	1.45			26th	.56	
	6th	1.65			27th	.22	
	7th	.14			29th	1.89	
	10th	.80			31st	.26	7.79
	13th	.11	5.80	September, 1922 ...	1st	1.14	
	16th	.03			2nd	.11	
	18th	.47			3rd	.23	
	19th	.27			4th	.52	
	20th	.50			5th	.26	
	21st	.84			6th	.39	
	23rd	.11			7th	1.09	
	24th	.04			8th	1.07	
	26th	2.30			11th	.05	4.85
	27th	.57			19th	1.41	
	29th	.19	5.82		20th	.71	
August, 1922	1st	1.52			21st	.60	
	2nd	2.98			22nd	.10	
	3rd	.28			23rd	.02	2.84
	4th	4.20		December, 1922 ...	23rd	.48	.48
	5th	2.88		January, 1923 ...	18th	.16	.16
	6th	.30		February, 1923 ...	10th	.34	
	7th	.60			11th	.10	.44
	8th	.18	12.94		16th	.07	.07
	17th	.06		May, 1923 ...	22nd	.08	.08
				Total ...	...	...	42.47

## APPENDIX C.

*Ten years' monsoon rainfall, Cawnpore Farm, 1913-1922.*

Period.	1922.	1921.	1920.	1919.	1918.	1917.	1916.	1915.	1914.	1913.	Ave- rage.	
June ... {	1st half	·74	·48	...	·13	·82	·98	5·76	·01	·40	1·54	1·08
	2nd ,,	·96	10·17	1·6	...	·91	2·36	7·02	3·85	...	4·62	3·15
July ... {	1st ,,	5·80	·37	1·50	6·14	1·03	2·55	5·14	3·57	6·10	2·45	3·47
	2nd ,,	5·32	3·05	12·00	3·48	·43	8·10	9·20	5·84	3·83	1·21	5·25
August .. {	1st ,,	12·94	10·05	2·49	3·62	·01	4·60	4·57	4·46	3·63	4·51	5·59
	2nd ,,	7·79	13·67	·02	3·55	5·30	1·06	4·41	17·93	2·80	1·62	5·86
September ... {	1st ,,	4·55	5·53	·11	5·29	1·28	3·48	1·36	12·05	3·55	5·49	4·30
	2nd ,,	2·84	·76	·03	·42	...	7·05	3·32	8·34	3·79	·12	2·65
October ... {	1st ,,	..	...	...	·89	...	·02	1·93	1·65	...	...	·45
	2nd ,,	...	...	...	...	...	2·21	...	...	...	...	·22
Total ...	41·24	44·08	17·75	28·52	9·78	33·31	42·71	57·67	23·60	21·56	32·02	

## APPENDIX D.

*Statement showing temperature at the Government Experimental Farm, Caunpore.*

Month.	Fortnightly mean temperature.		8 a. m.	For fortnight.		
	Maximum.	Minimum.		Maximum.	Minimum.	
June ...	{ 1st half	105	81	88	112	69
	{ 2nd "	102	83	89	110	78
July ...	{ 1st "	91	79	82	104	74
	{ 2nd "	89	78	81	97	72
August ...	{ 1st "	86	76	79	92	75
	{ 2nd "	87	77	81	92	74
September	{ 1st "	89	78	82	95	76
	{ 2nd "	87	74	79	95	70
October ...	{ 1st "	85	66	77	92	60
	{ 2nd "	85	59	72	92	55
November	{ 1st "	84	60	66	88	54
	{ 2nd "	79	58	59	83	50
December	{ 1st "	76	53	57	61	51
	{ 2nd "	70	48	52	75	43
January ...	{ 1st "	73	44	47	79	37
	{ 2nd "	76	49	53	81	41
February ...	{ 1st "	79	53	57	82	48
	{ 2nd "	76	48	55	79	40
March ...	{ 1st "	87	54	63	94	49
	{ 2nd "	97	63	75	107	54
April ...	{ 1st "	102	69	81	105	63
	{ 2nd "	104	73	85	109	67
May ...	{ 1st "	107	77	90	110	71
	{ 2nd "	107	77	92	112	70

APPENDIX E.

Quantity and composition of drain gauge waters, monsoon 1922.

Period.	Rain in inches.	No. 1, 6' gauge.			No. 2, 6' gauge.			No. 3, 3' gauge.			No. 4, 3' gauge.		
		Drainage in inches.	Nitric nitrogen.		Drainage in inches.	Nitric nitrogen.		Drainage in inches.	Nitric nitrogen.		Drainage in inches.	Nitric nitrogen.	
			Parts per million.	Pounds per acre.		Parts per million.	Pounds per acre.		Parts per million.	Pounds per acre.		Parts per million.	Pounds per acre.
June, 1st to 15th ...	·74	...	..	...	...	...	...	...	...	...	...	...	...
June, 16th to 30th ...	·96	...	...	...	...	...	...	...	...	...	...	...	...
July, 1st to 15th ...	5·80	...	...	...	...	...	...	...	...	...	...	...	...
July, 16th to 31st ...	5·32	·850	3·572	·687	...	...	...	2·360	11·870	6·349	2·190	10·453	5·201
August, 1st to 15th ...	12·94	10·137	8·092	18·611	9·339	7·881	16·702	10·524	5·682	13·568	10·837	6·313	15·524
August, 16th to 31st ...	7·79	3·185	6·576	4·753	3·554	5·347	4·312	3·963	1·718	1·545	4·081	2·143	1·989
September, 1st to 15th ...	4·85	3·910	6·975	6·159	3·671	3·607	3·005	3·976	1·525	1·375	4·094	1·849	1·717
September, 16th to 30th ...	2·84	·398	3·666	·331	·397	5·496	·495	·593	1·328	·179	·790	1·495	·268
October, 1st to 15th ...	...	·028	4·556	·0237	·009	16·338	·0353	...	...	...	...	...	...
Total ...	41·24	18·508	33·437	30·5637	16·970	38·669	24·5493	21·415	22·123	23·016	21·992	22·263	24·699

## II.—ORAI EXPERIMENT STATION.

## CHAPTER I.

## Situation, area and soil.

This farm is situated near the Orai station and consists of four blocks of land in different villages. The area is 87 acres of which 13½ acres are occupied by roads and buildings. The farm is irrigated to a limited extent in the rabi season only from the Orai distributary of the Hamirpur branch, Betwa canal. The soils have been described in previous reports; none of them are typical except perhaps of second class *kabur*. The canal supply is most uncertain as the farm is situated at the tail of a bad channel. In many years this farm is of little use for experimental purposes. The canal supply is so uncertain as to make experiments with irrigated crops unsatisfactory. This farm has, under the orders of Government, now been closed.

## CHAPTER II.

## (a) Wheat and gram.

The following are the average yields of rabi crops in pounds per acre obtained on the farm during the year under report:—

Variety.	Area sown in acres.	Grain	Straw.
	<i>Wheat.</i>		
Pusa 4     ...     ...	7.95	518	1,325
Pusa 12   ...     ...	11.70	765	2,051
Soharia   ...     ...	4.84	615	820
	<i>Gram.</i>		
Local     ...     ...	19.11	750	1,192
	<i>Wheat and gram mixed.</i>		
Wheat     ...     ...     }	1.8	679	1,488
Gram      ...     ...     }		1,219	1,943

## (b) Cotton.

The cotton crop on the farm both for seed production and varietal tests was a total failure no plot yielding more than 127 lbs. kapas per acre. No conclusions can thus be drawn from the figures obtained.

## (c) Arhar.

A repetition of the varietal tests carried out in the preceding year was again undertaken, but the heavy and continuous rains practically destroyed the crop and all the outturns were so low and uneven that no reliable conclusions can be drawn.

## (d) Juar.

A comparison of Andhri, Ghasua and Cawnpore dodania juars for seed production was again carried out but owing to the excessive rains weeding and cultivation could not be done and the outturns are poor.



*Yield in pounds per acre.*

Andhri juar (local).		Cawnpore dodania juar.		Ghasua juar.		Remarks.
Grain.	Straw.	Grain.	Straw.	Grain.	Straw.	
750	6,725	485	2,480	935	6,465	Average of 2 <sup>1</sup> / <sub>10</sub> acre plots.
690	5,580	355	2,670	598	1,335	Ditto All plots were sown at 10 lbs. seed per acre.

2.72 acres of Ghasua juar grown for seed yielded 291 lbs. grain and 2,196 lbs. straw per acre. In the previous year Andhri juar yielded an average of 746 lbs. grain per acre, Cawnpore dodania 657 lbs. and Ghasua 777 lbs. grain per acre.

*(e) Bajra and arhar.*

All trials with these crops were spoiled by excessive rain and the results obtained are not comparable.

## APPENDIX A.

Statement showing rainfall at the Government Experimental Station, Orai.

Month.	Date.	Daily rainfall.	Fort-nightly total.	Month.	Date.	Daily rainfall.	Fort-nightly total.
June, 1922 ...	2nd	.10		August, 1922 ...	7th	0.08	
	3rd	.78			12th	0.12	7.99
	9th	.52	1.40		18th	0.01	
	23rd	1.04			19th	1.85	
	24th	.07	1.11		2.4th	.05	
July, 1922 ...	3rd	.18			21st	.29	
	4th	.32			22nd	1.20	
	5th	1.12			23rd	.69	
	6th	1.05			25th	.12	
	7th	.94			26th	.20	
	12th	.34			29th	.08	
	13th	.34			30th	.52	
	14th	.72			31st	.31	5.27
	15th	.47	5.48	September, 1922	1st	1.08	
	16th	1.20			2nd	.04	
	17th	.06			3rd	.02	
	18th	0.14			4th	.36	
	19th	.06			5th	1.40	
	20th	0.86			6th	1.38	
	21st	1.32			9th	1.10	
	22nd	0.04			11th	.26	
	23rd	0.27			13th	.16	5.75
	24th	0.87			17th	.08	
	25th	0.22			18th	.09	
	26th	3.85			19th	.03	
	27th	0.40			20th	.32	
	28th	0.05			21st	.04	
	29th	1.09		December, 1922	24th	.14	.65
	30th	0.08	10.97		13th	.10	.10
	31st	0.46			23rd	.45	.45
August, 1922 ...	1st	1.19		January, 1923	13th	.28	.28
	2nd	2.18		February, 1923	10th	.04	.04
	8rd	1.05			16th	.04	.04
	4th	1.86					
	5th	1.86					
	6th	0.15					
				Total	...	...	89.00

## APPENDIX B.

Statement showing temperature at the Orat Agricultural Station  
from 1st June, 1922, to May, 1923.

Month.	Temperature in shade.		Actual temperature in shade at 8 a.m.		
	Maximum.	Minimum.	Maximum.	Minimum.	
June, 1922	{ 1st half	99.2	74.06	84.2	84.2
	{ 2nd "	96.6	79.46	87.93	87.93
July, 1922	{ 1st "	88.8	74.73	81.3	81.33
	{ 2nd "	85.81	74.00	78.56	78.56
August, 1922	{ 1st "	83.46	73.8	76.8	76.8
	{ 2nd "	87.81	79.6	76.87	76.87
September, 1922	{ 1st "	89.8	75.2	79.93	79.93
	{ 2nd "	89.93	72.00	75.74	75.74
October, 1922	{ 1st "	92.53	64.53	73.86	73.86
	{ 2nd "	91.75	56.67	71.12	71.12
November, 1922	{ 1st "	87.46	53.4	64.8	64.8
	{ 2nd "	82.06	45.86	55.00	55.00
December, 1922	{ 1st "	79.63	66.8	56.46	56.46
	{ 2nd "	72.5	41.00	50.12	50.12
January, 1923	{ 1st "	74.8	38.45	48.33	48.33
	{ 2nd "	76.88	41.31	47.62	47.62
February, 1923	{ 1st "	82.26	48.26	56.00	56.00
	{ 2nd "	77.11	43.61	56.48	56.48
March, 1923.	{ 1st "	89.2	47.75	61.86	61.86
	{ 2nd "	99.37	60.81	77.38	77.38
April, 1923	{ 1st "	102.53	70.74	81.73	81.73
	{ 2nd "	102.23	66.2	87.2	87.2
May, 1923	{ 1st "	107.74	76.06	88.53	88.53
	{ 2nd "	107.06	77.43	86.25	86.25

### III.—ATTARA FARM, DISTRICT BANDA.

#### CHAPTER I.

##### Situation, area and soils.

This farm, area 171 acres, is situated on the Ken Canal about half a mile from Attara station on the Manikpur-Jhansi branch of the Great Indian Peninsula Railway and is 21 miles by road from Banda.

The soil of this tract is *parva* shading off into *kabar*; with irrigation it is suitable for most crops, without irrigation it is suitable for wheat in favourable years and for *juar* in the kharif. The lower lying land grows rice.

Cotton has not done well at this farm in the past but sugarcane is a valuable crop which can be grown provided labour and irrigation are available.

#### CHAPTER II.

##### (a) Wheat.

61.91 acres Pusa 4 were grown for seed supply and yielded an average of 979 lb. grain per acre and 1,346 lb. straw.

Three-quarters of an acre each of C. 13 and Pusa 12 were also grown and yielded respectively 1,437 lb. and 1,100 lb. grain and 2,117 lb. and 1,778 lb. straw.

##### (b) Gram.

28.81 acres gram grown for seed supply yielded 785 lb. grain and 850 lb. straw per acre.

##### (c) Peas.

6.39 acres of peas yielded 705 lb. grain and 581 lb. straw per acre.

The results of the above crops are not good but the yield was reduced by rust and the early commencement of hot winds. The whole farm also is suffering from lack of manure though green manuring has been carried out as much as is practicable.

##### (d) Rice.

In continuation of trials carried out during the past two years certain varieties of rice were again tested with the following results. Bansi, Londi and Badshahpasand varieties were dropped owing to the inferior results they had given in previous years.

All yields in pounds per acre.

Varieties.	Transplanted.		Broadcast.		Remarks.
	Grain.	Straw.	Grain.	Straw.	
Sonkarcha, white ...	864	2,365	} 420	1,410	1. All plots unmanured. 2. Transplanted rices sown in nursery on the 18th June, 1922, and transplanted on the 1st August, 1922. 3. Broadcast rices sown on the 15th July, 1922, at 40 lb. seed per acre. 4. No irrigations given.
Do. red ...	1,014	1,501			
Ramjawain ...	352	1,226	323	1,188	
Banko ...	1,829	2,660	950	1,770	
Indra ...	1,144	1,938	415	1,185	
Parewa ...	1,377	3,154	560	1,385	

As in previous trials Banko has proved a consistent yielder but Parewa which had formerly done best has not this year come up to expectations.

In view of the results obtained in previous years 4.02 acres of Parewa dhan was sown for seed production and yielded an average of 737 lb. grain and 1,803 lb. straw per acre.

(e) Cotton.

Owing to heavy and continuous rain all cotton sown on the farm proved a failure and was ploughed in. A chess board trial carried out to ascertain the comparative yield of varieties of cotton, i.e., J. N. 1, Aligarh White Flower and two varieties of K. 22 was also destroyed by the heavy rain.

(f) Maize.

A small plot of Muzaffarnagar maize grown with well irrigation yielded 1,360 lb. cobs and 4,436 lb. straw per acre.

(g) Bajra.

Awned bajra yielded 448 lb. grain per acre and 1,760 lb. straw, local desi bajra yielded 368 lb. grain and 1,600 lb. straw per acre. This bears out results obtained in previous years when awned bajra has proved a superior yielder to the local variety.

(h) Groundnut.

Two acres of large Virginia groundnut yielded 1,309 lb. of dry nuts per acre.

(i) Juar.

Certain of the series of juar which had been grown in former years were again tried with the following results :—

Yield in pounds per acre.

Variety.	Grain.	Straw.	Remarks.
Andhri ... ..	236	1,600	Plots were re-sown twice owing to excessive rainfall washing seedlings out of the ground. All plots harvested on the 13th to 15th December, 1922. Previous crop, gram and wheat, without manure.
Cawnpore dodania ... ..	237	1,456	
Ghasua ... ..	700	4,020	
Badmashia ... ..	52	800	

The outturns obtained are very poor owing to the excessive rainfall but Ghasua juar has again demonstrated its superiority.

Cawnpore dodania juar grown for fodder yielded 9,924 lb. green fodder per acre.

(j) Sugarcane.

The results of this crop are given below. As last year a higher total yield was obtained from trench sowings while the percentages of juice to

cane, gur to juice and gur to cane are nearly equal in both trench and flat sowings :—

Variety.	Outturn per acre in lbs.						Remarks.
	Juice.	Gur.	Gur.	Cane.	Juice.	Gur.	
	Cane.	Juice.	Cane.				
<i>Trench sowing.</i>							
S. 48 ...	57.70	15.23	8.78	39,188	22,631	3,444	Sown in trenches at 4' distance, manured with Sanai green manure and 80 maunds mahua cake per acre.
S. 89 ...	59.95	15.66	9.39	28,116	16,856	2,640	
A. 42 ...	55.24	14.97	8.32	26,440	14,750	2,200	
<i>Flat sowing.</i>							
S. 48 ...	59.75	15.34	9.17	36,542	21,833	3,346	Sown flat behind plough. Manured with sanai green manure and 80 maunds mahua cake per acre.
S. 89 ...	59.89	14.90	8.77	35,362	20,824	3,106	
A. 42 ...	57.28	16.42	9.44	46,026	26,352	4,323	

A small area of *pounda* cane was also grown.

(k) Sanai.

17.15 acres *sanai* were grown and ploughed in as green manure in preparation for the wheat crop.

(l) Til.

Small areas of black and white til were grown for seed and yielded respectively 172 and 102 lbs. seed per acre.

(m) Arhar.

Local white and early varieties of *arhar* were again tested for yielding capacity with the following results :—

Variety.	Average outturn in lbs. per acre.		Remarks.
	Grain.	Straw.	
Early ...	520	1,924	Early Unao <i>arhar</i> has given a very poor yield owing to being damaged by heavy rains. As in previous trials the local and white varieties are practically equal in yield.
Local ...	1,408	5,180	
White ...	1,441	4,832	

APPENDIX A.

*Character of the season.*

The monsoon of 1922 was weak during the second half of June but gave copious rain from July to third week of September on account of which the weeding of *kharif* crop and preparation of land for *rabi* sowing were held up. The rains eventually proved so heavy and continuous that the greater part of *kharif* sown failed totally and was ploughed in. An increased area of *rabi* was therefore sown and promised to be a good crop but rust and the hot winds at harvest time reduced the yield of the wheat crop. On the whole the yields are poor and not as good as were expected.

## APPENDIX B.

Statement showing the daily rainfall at the Atarra Government  
Experiment Station, district Banda.

Month and date;	Daily rainfall in inches.	Fort- nightly total in inches.	Month and date.	Daily rainfall in inches	Fort- nightly total in inches.
June, 1922 1st ...	.01	.01	August, 1922 7th	.28	
" 19th ...	.02		" 18th	.05	12.87
" 22nd ...	.14		" 18th	.45	
" 28th ...	.04		" 19th	1.20	
" 30th ...	.16	.86	" 20th	.87	
July, 1922 1st ...	.10		" 21st	1.80	
" 2nd ...	.08		" 22nd	.70	
" 5th ...	1.97		" 23rd	.01	
" 6th ...	.16		" 25th	.01	
" 7th ...	.84		" 26th	.24	
" 9th ...	.24		" 27th	.40	
" 10th ...	1.61		" 29th	.57	
" 12th ...	.81		" 30th	.66	
" 18th ...	.91		" 31st	.87	6.88
" 14th ...	.79		September, 1922 1st	8.16	
" 15th ...	.08	6.45	" 2nd	.58	
" 16th ...	.04		" 3rd	.14	
" 18th ...	.41		" 4th	.85	
" 19th ...	.56		" 5th	2.41	
" 20th ...	1.07		" 6th	.64	
" 21st ...	.47		" 7th	.02	
" 22nd ...	.05		" 8th	1.81	
" 23rd ...	.86		" 9th	.02	9.18
" 25th ...	2.43		" 17th	.03	
" 26th ...	6.11		" 18th	1.10	
" 27th ...	.12		" 19th	.67	
" 28th ...	.10		" 20th	.11	
" 29th ...	.02		" 21st	.01	
" 30th ...	.67	12.91	" 22nd	.02	
August, 1922 1st ...	.72		" 23rd	.41	
" 2nd ...	8.58		" 24th	.56	2.91
" 3rd ...	.11		December, 1922 23rd	.14	.14
" 4th ...	4.0		February, 1923 10th	.08	.08
" 5th ...	3.38		" 16th	.08	
" 6th ...	.85		" 24th	.41	.49
			Total ...		51.78



## APPENDIX C.

Statement showing the mean temperature at the Atarra Government  
Experiment Station, district Banda.

Month.	Temperature in shade.		Actual temperature in shade.			
	Maximum.	Minimum.	Maximum.	Minimum.	Mean.	
June, 1922 ...	1st half ...	107.53	70.66	85.8	86.8	83.30
	2nd ,, ...	102.20	76.0	81.0	82.0	81.50
July, 1922 ...	1st half ...	87.80	73.27	76.2	77.2	76.70
	2nd ,, ...	83.87	73.94	75.62	76.62	76.12
August, 1922 ...	1st half ...	81.80	71.53	74.13	75.13	74.63
	2nd ,, ...	85.25	73.55	74.87	75.87	75.37
September, 1922 ...	1st half ...	85.80	74.07	77.27	78.27	77.77
	2nd ,, ...	85.13	70.80	74.60	75.60	75.10
October, 1922 ...	1st half ...	87.33	63.80	72.20	73.20	72.70
	2nd ,, ...	87.81	56.87	66.62	67.62	67.12
November, 1922 ...	1st half ...	87.66	53.06	60.73	61.73	61.23
	2nd ,, ...	80.20	46.93	52.86	53.86	53.36
December, 1922 ...	1st half ...	77.60	53.00	51.46	52.46	51.96
	2nd ,, ...	74.31	39.94	46.63	47.63	47.12
January, 1923 ...	1st half ...	73.13	37.20	46.06	47.06	46.56
	2nd ,, ...	75.19	38.75	46.94	47.94	47.44
February, 1923 ...	1st half ...	79.60	42.6	55.87	56.87	56.87
	2nd ,, ...	79.00	42.00	54.00	55.00	54.50
March, 1923 ...	1st half ...	86.53	49.26	68.13	69.13	68.63
	2nd ,, ...	94.25	61.50	73.12	74.12	73.62
April, 1923 ...	1st half ...	98.47	69.07	78.87	79.87	79.37
	2nd ,, ...	105.33	64.52	85.2	86.2	85.70
May, 1923 ...	1st half ...	108.6	69.4	82.47	83.47	82.97
	2nd ,, ...	110.69	72.06	81.81	82.81	81.81

## IV.—ETAWAH FARM.

### CHAPTER I.

#### SITUATION, AREA, AND SOILS.

This farm occupies about 61 acres of *nazul* land near the Etawah civil station and is primarily intended for demonstrations and seed-supply and is also used for variety testing and local experiment. The whole area is irrigable from the Etawah distributary, Bhognipur branch, Lower Ganges canal, and the soil is fairly typical of the district. The farm is managed departmentally. During the year under report considerable damage to the farm crops has been experienced from wild animals harboured in the Fisher Forest.

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### CHAPTER II.

#### EXPERIMENTS WITH PARTICULAR CROPS.

##### (a) Wheat.

Fifteen acres of Pusa 12 wheat grown for seed production yielded an average of 1,595 lb. per acre of grain. The crop was damaged during its growth by the attacks of wild pigs.

##### (b) Gram.

7.3 acres of gram grown for seed production yielded an average outturn of 1,629 lb. grain per acre. This crop was also damaged by animals.

##### (c) Peas.

10.75 acres of peas grown *do-fashi* yielded 545 lb. grain per acre and 1,008 lb. straw.

##### (d) Sugarcane.

Two and three-quarters acres of medium and thin cane were grown during the year with the following results :—

SUGARCANE VARIETIES.

Area in acres.	Variety.	Date of sowing.	Number of irrigations with date.	Date of harvesting.	Outturn per acre in lbs.		Remarks.
					Number of canes.	Weight of canes.	
0.50	S.50 Sugarcane ...	15th to 17th February, 1922.	<i>Trench sowing.</i> 11th to 12th March, 1922, 6th to 7th April, 1922, 4th to 18th May, 1922, 28rd to 24th May, 1922, 20th to 21st June, 1922, 30th to 31st June, 1922, (6).	December, 1922, to March, 1923.	84014	65160	Both trench and flat sown cane was planted at a distance of 4' apart. Trench sown cane was manured with 40 maunds castor cake per acre and flat sown with 30 maunds per acre. Previous crop in both cases was gram unmeasured.
0.50	S.48 Ditto ...	Ditto ...	Ditto ...	Ditto ...	84456	68912	
0.50	S.89 Ditto ...	Ditto ...	Ditto ...	Ditto ...	44276	66416	
			<i>Sown Flat.</i>				
0.25	S.50 Ditto ...	17th to 20th February, 1922.	10th to 11th March, 1922, 31st March, 1922, 4th April, 1922, 3rd to 6th May, 1922, 12th May, 1922, 21st to 23rd May, 1922, 21st to 22nd June, 1922, 31st October, 1922, 1st November, 1922, (7).	Ditto ...	30020	49412	
0.25	S.49 Ditto ...	Ditto ...	Ditto ...	Ditto ...	22732	37086	
0.25	S.89 Ditto ...	Ditto ...	Ditto ...	Ditto ...	35272	46292	
0.25	A.42 Ukh ...	Ditto ...	Ditto ...	Ditto ...	54540	42260	
0.23	Matna ukh ...	Ditto ...	Ditto ...	Ditto ...	51920	38600	

( 25 )

No crushings were carried out the cane being sold for seed to zamindars and cultivators of the district. The results obtained are considerably better than in the previous year.

## (e) Cotton.

During the year under report this crop did badly, being much damaged by the heavy rain which fell at flowering time. 1.35 acres Cawnpore American cotton grown for seed production yielded 201 lb. kapas per acre, the average yield during the previous year being 593 lb. per acre. J. N. 1 cotton was not grown on this farm during the previous year.

## J. N. 1 Cotton.

Area.	Date of sowing.	Irrigations.	Yield, kapas in lb. per acre.	Remarks.
1.90	23rd May, 1922, at 18 seers with palewa.	22nd June, 1922.	109	Previous crop C-13 wheat matured.
2.75	26th May, 1922, at 22 seers with palewa.	23rd June, 1922.	155	Pusa 12 unmanured.
1.35	26th May, 1922, at 13 seers with palewa.	Nil	254	Pusa 12 manured.

## (f) Arhar.

7.10 acres Unao early arhar were grown after Pusa 12 wheat and yielded 1,437 lb. grain and 959 lb. straw per acre. This yield is up to the average.

## (g) Juar.

Cawnpore Dodania juar was grown for karbi and mixed with guar for green fodder. 4.0 acres grown for karbi yielded an average of 8,034 lb. dry fodder per acre and 3.40 acres Cawnpore Dodania juar mixed with guar yielded an average of 14,568 lb. green fodder per acre.

## (h) Bajra.

One acre of awned bajra grown for seed production yielded 895 lb. grain and 4,598 lb. straw per acre.

## (i) Sanai.

1.65 acre of sanai grown for fibre yielded an average of 147 lb. dry fibre per acre.

APPENDIX A.

*Character of the season.*

The monsoon was weak during the first half of July, but gave copious rain during the second half of July. Continuous rain during August and September damaged the flowering cotton and juar crops considerably and preparation for rabi crops was also delayed. During October and November there was no rainfall. Light showers fell in December and February, which had a beneficial effect on all standing crops. During the year all crops on the farm were healthy and no fungoid or insect pests made their appearance.

## APPENDIX B.

Statement showing the daily rainfall at the Government District  
Farm, Etawah.

Month and date.		Rainfall in inches.	Fort- nightly total.	Month and date.		Rainfall in inches.	Fort- nightly total.	
June,	2nd ...	0.57	1.54	August,	18th ...	0.32		
	3rd ...	0.97			19th ...	0.69		
	23rd ...	0.71	20th ...		0.12			
	24th ...	0.08	21st ...		0.99			
	30th ...	0.63	22nd ...		0.27			
July,	2nd ...	0.19	1.42	25th ...	0.13	4.20		
	4th ...	0.18		26th ...	0.88			
	7th ...	0.66	27th ...	0.82				
	12th ...	0.44	31st ...	0.98				
	13th ...	0.01	September,	1st ...	0.26			
	17th ...	0.19		2nd ...	0.75			
	18th ...	0.06		3rd ...	0.01			
	19th ...	0.85		4th ...	0.01			
	20th ...	0.83		5th ...	0.04			
	21st ...	0.09		6th ...	0.73			
	22nd ...	0.72		7th ...	0.01			
	25th ...	0.10		8th ...	0.12			
	26th ...	4.01		15th ...	0.10			
27th ...	0.14	16th ...		0.06				
29th ...	0.35	19th ...		0.80				
31st ...	0.86	20th ...		0.01				
August,	1st ...	0.60		7.70	21st ...	0.10	2.03	
	2nd ...	0.86	23rd ...		0.01			
	3rd ...	1.46	24th ...		0.06			
	4th ...	0.20	December,		13th ...	0.20		
	5th ...	0.60			23rd ...	0.22		
	6th ...	0.65			February,	23rd ...		0.21
	7th ...	0.12				24th ...		0.23
	11th ...	0.06			Total	...		...
	12th ...	0.01				4.56		...

APPENDIX C.

Statement showing the mean temperature at Government District Farm, Etawah.

Month.				Fortnightly mean temperature in shade.		At 8 a.m.
				Maximum.	Minimum.	
June	{ 1st half	...	...	95.9	72.8	85.6
	{ 2nd "	...	...	101.9	79.8	88.4
July	{ 1st half	...	...	98.4	76.1	84.2
	{ 2nd "	...	...	88.8	74.5	78.8
August	{ 1st half	...	...	86.2	73.0	77.0
	{ 2nd "	...	...	87.0	74.8	78.1
September	{ 1st half	...	...	88.5	74.5	79.4
	{ 2nd "	...	...	88.8	69.6	77.0
October	{ 1st half	...	...	92.4	61.7	75.4
	{ 2nd "	...	...	91.9	56.1	70.4
November	{ 1st half	...	...	86.8	52.5	68.0
	{ 2nd "	...	...	80.4	48.6	55.9
December	{ 1st half	...	...	78.6	48.4	54.2
	{ 2nd "	...	...	69.1	40.8	48.0
January	{ 1st half	...	...	71.1	39.0	44.2
	{ 2nd "	...	...	73.1	40.5	47.9
February	{ 1st half	...	...	77.8	48.0	54.4
	{ 2nd "	...	...	73.1	43.2	50.7
March	{ 1st half	...	...	85.0	49.0	59.5
	{ 2nd "	...	...	96.7	58.2	73.0
April	{ 1st half	...	...	101.9	65.5	79.6
	{ 2nd "	...	...	105.8	65.9	83.8
May	{ 1st half	...	...	107.2	73.8	89.0
	{ 2nd "	...	...	108.5	75.0	90.8

**V.—HARDOI DISTRICT FARM.****CHAPTER I.****SITUATION, AREA AND SOILS.**

This farm is situated near the Hardoi civil station and occupies about 40 acres of light land now irrigable from a Brownlie tube well. When taken over the land had been badly depreciated by erosion, but this has now been almost entirely remedied by draining and terracing, but it will be some years before the fields are uniform. The farm is financed by the Hardoi district board, which takes receipts and meets working expenditure, the supervising staff being provided by the department.

**CHAPTER II.****(a) Wheat.**

6.6 acres Pusa 12 grown for seed production yielded 1,771 lbs. grain and 3,679 lbs. straw per acre. This is approximately 22 maunds grain and 45 maunds straw per acre. The crop showed considerable promise in its early stages but the final yield did not come up to expectations.

*Trials of new Pusa wheats.*

These trials were again carried out with the results given below and as was expected Pusa 54 has again proved its superiority. This variety will now be adopted for distribution in conjunction with Pusa 12 and Pusa 4 when a sufficient quantity of pure seed has been multiplied up on Government farms:—

Variety.	Average yield in lbs. per acre.		Remarks.
	Grain.	Straw.	
Pusa 12 ... ..	1800.2	4372.1	Sown behind country plough at 75 seers per acre on 25th October, 1922. Two irrigations, previous crop half sugarcane manured with castor and mahua cake and half maize.
" 51 ... ..	1721.9	3740.7	
" 52 ... ..	1465.6	3621.1	
" 54 ... ..	1982.9	4024.9	
" 55 ... ..	1801.5	3938.8	
" 56 ... ..	1724.4	4087.9	
" 59 ... ..	1557.2	3560.7	
C. 13 ... ..	1455.6	2957.6	
C. 46 ... ..	1763.0	3391.0	

**(b) Cotton.**

2.2 acres of J. N. 1 cotton grown for seed production yielded an average of 260 lbs. kapas per acre. This outturn is very poor, but the crop was badly damaged by rains especially in September.

**(c) Groundnuts.**

3.2 acres of Japanese groundnuts grown for seed production yielded an outturn of 1,752 lbs. per acre. This is a very satisfactory yield, being over 21 maunds per acre.



## (d) Arhar.

1.75 acres of this crop grown for seed production yielded 937 lbs. per acre. This yield is not up to the average but owing to heavy and continuous rains soon after sowing time the growth of the crop was badly checked.

## (e) Juar.

One acre of Cawnpore dodania juar grown for seed yielded 905 lbs. per acre. This crop also suffered from excess of rain.

## (f) Sugarcane.

During the year under report this crop was as usual the most important on the farm. Owing to the fall in price of all agricultural produce and the high cost of labour coupled with the necessity of showing a profit on the working of the farm, as much of the cane crop as possible was sold for seed and for chewing purposes, thus doing away with the heavy expenditure on labour necessitated on *rab* manufacture. The area of cane sown was just over nine acres, being nearly double the area of the previous year.

Table showing details of yields in maunds and seers.

Variety.	Outturn per acre.			Percentage of juice to cane.	Percentage of <i>rab</i> to cane.	Percentage of <i>rab</i> juice.	Remarks.
	Stripped cane.	<i>Rab</i> .	<i>Qsr</i> .				
		Mds. sr.	Mds. sr.				
S. 48 ...	1,000	...	...	Sold for seed.			Sown in trenches 4 feet apart, manured with 300 maunds dung, 20 maunds mahua cake and 5 maunds castor cake per acre. Four irrigations; previous crop wheat.
S. 50 ...	780	...	...	Sold for chewing.			
S. 39 ...	887	108 2	...	61.23	12.3	30.8	
S. 48 ...	929	...	...	Sold for seed.			Sown in trenches 3½ feet apart. Manured 300 maunds dung, 20 maunds mahua cake and 10 maunds castor cake per acre. Four irrigations; previous crop cotton and groundnuts.
S. 50 ...	744	...	...	Sold for chewing.			
S. 39 ...	912	...	...	Sold for seed.			
S. 48 ...	815	102 35	...	63.47	12.62	19.88	Sown flat, manured with dung at 280 maunds per acre and castor cake at 10 maunds per acre. Three irrigations; previous crop cotton and groundnuts.
S. 50 ...	625	84 20	...	63.13	12.95	19.01	
S. 39 ...	701	...	82 14	63.24	10.41	15.25	
S. 39 ...	889	178 0	...	60.51	12.14	17.47	
A. 43 ...	538	...	51 20	55.15	9.57	17.35	
A. 43 ...	625	48 13	...	50.09	9.19	18.35	

APPENDIX A.

*Character of the season.*

Little rain was received in June but from July onwards to September rain was heavy and continuous and the *kharif* crops both of the district and the farm suffered severely—except the cane crop which did well. Moisture at *rabi* sowing was sufficient and the crop came on well but rain in February followed by wind after the second irrigation caused some lodging. The crop was also slightly affected with rust and therefore the outturn was not up to expectations.

## APPENDIX B.

Statement showing rainfall at Hardor farm, 1st June, 1922, to  
31st May, 1923.

Month and date.	Rainfall in inches.	Fortnightly total.	Month and date.	Rainfall in inches.	Fortnightly total.	
June, 2nd ...	.82	.82	August, 17th ...	.84	8.70	
23rd ...	.12		18th ...	.93		
28th ...	.16		19th ...	2.62		
30th ...	.12		20th ...	1.18		
July, 3rd ...	.20	2.67	21st ...	.05		
5th ...	.78		22nd ...	.09		
6th ...	1.43		23rd ...	.02		
7th ...	.06		24th ...	.25		
13th ...	.10		25th ...	1.50		
14th ...	.10		26th ...	.75		
17th ...	.05		27th ...	.25		
18th ...	.55		28th ...	.25		
19th ...	3.95		29th ...	.30		
20th ...	.80		31st ...	.17		
21st ...	.12		7.49	September, 2nd ...	.15	
22nd ...	.06	3rd ...		.83		
23rd ...	.41	4th ...		1.00		
24th ...	.04	5th ...		.17		
26th ...	.62	6th ...		.95		
26th ...	.48	7th ...		.12		
27th ...	.85	8th ...		.27		
29th ...	.05	9th ...		.08		
August, 1st ...	.37	9.45		19th ...	1.11	
2nd ...	.85			20th ...	.47	
3rd ...	.04			21st ...	1.33	
5th ...	1.00		22nd ...	.31		
6th ...	3.25		23rd ...	1.16		
7th ...	.08		29th ...	.45		
8th ...	4.30		February, 11th ...	.84	.84	
11th ...	.16			23rd ...		.11
				24th ...		.09
				Total ...		88.96

## VI.—MAINPURI DISTRICT FARM.

## CHAPTER I.

## SITUATION, AREA AND SOILS.

This farm, some 52 acres in area, is situated near the Kachehri Railway Station, Mainpuri. The soil is for the most part *bhur* shading off into a poor loam towards the south-east side of the farm. Bad *usar* patches occur in places which together with the unevenness of the soil make the results of any trials and comparisons of varieties of very little value. The farm has now been levelled and a system of cropping adopted by which it is hoped that these defects may be to some extent eradicated. A Chaudhri well with an oil engine has also been installed and with the aid of this it will doubtless be possible to place a larger area of the farm under *rabi* and thus improve its financial position.

## CHAPTER II.

## (a) Wheat.

Pusa 12 grown for seed supply gave the following yields in lb. per acre:—

Area in acres.	Previous crop.	Manure.	Yield.		Date sown.	Remarks.
			Grain.	Straw.		
1.8	Peas without manure.	Dung at 115 maunds per acre.	973	1,678	26th October, 1922, at 120 lbs. per acre.	All fields received three irrigations.
1.8	Do. ...	Dung at 140 maunds per acre.	1,144	2,034	25th October, 1922, at 120 lbs. per acre.	
.90	Sugarcane manured.	Nil ...	1,472	2,427	23rd October, 1922, at 100 lbs. per acre.	
.88	Maize manured.	Nil ...	1,346.5	2,314.6	24th October, 1922, at 120 lbs. per acre.	
.80	Wheat manured.	Nil ...	957	1,519	24th October, 1922, at 120 lbs. per acre.	
2.0	Do. ...	Dung at 100 maunds per acre.	1,600	2,382	22nd October, 1922, at 100 lbs. per acre.	
1.00	Do. ...	Nil ...	843	1,320	27th October, 1922, at 100 lbs. per acre.	
1.00	Gram unmanured.	Nil. ...	1,116	1,916	23th October, 1922, at 116 lbs. per acre.	

Average yield 1,214 lbs. grain per acre and 1,948 lbs. straw per acre. In 1921-22 average yield of grain was 1,316 lb. per acre.

## (b) Gram.

2.1 acres of gram grown for seed production yielded 1,540 lbs. grain per acre.

A trial of various varieties of gram for yield was again carried out with the results given below :—

Variety.						Yield in lbs. per acre.
Gram Pusa no. 6	...	...	...	...	...	1,111
Do. 17 ..	...	...	...	...	...	1,008
Do. 18...	...	...	...	...	...	1,059
Do. 25...	...	...	...	...	...	977
Cawnpore gram ...	...	...	...	...	...	977

The area sown was this year in fairly uniform condition and the results obtained form some guide as to the suitability of these varieties for local cultivation.

(c) Cotton  
for  
Seed Production.

Area in acres.	Variety.	Outturn in lbs. per acre. Kapa.	Sowing.	Irrigations.	Previous crop.	Remarks.
1.80	J. N. 1	184	4-6-'22	17-6-22	Groundnuts without manure.	Sown without Palewa on poor bhur soil.
1.00	C. A. 9	357	17-5-'22	30-5-22	Gram without manure.	Sown with Palewa.
1.00	C. A. 9	358	15-5-'22	9-5-22	Peas without manure.	Ditto.

The above outturns are poor but as was the case with the general cotton crop of the neighbourhood these fields were damaged by heavy rains. The average yield of C. A. 9 cotton grown on the farm in 1921 was 430 lbs. kapa per acre.

A chess board trial carried out for the comparison of four varieties of cotton gave the following results :—

Variety.						Yield per acre in seers.
Raya ...	...	...	...	...	...	158 ± 59
A. W. F.	...	...	...	...	...	203 ± 267
J. N. 1	...	...	...	...	...	178 ± 142
K-22 sown 1' × 2'	...	...	...	...	...	196 ± 94
K-22 sown 18" × 2'	...	...	...	...	...	194 ± 94

All plots were sown at the rate of 10 lb- per acre. The trial suffered from excess of rain and the gaps which appeared were re-sown making the plots very uneven.

(d) Maize.

•8 acre of Jaunpur maize grown for seed, production yielded 570 lbs. grain per acre.

(e) Rice.

•92 acre of Sathi rice grown for seed production yielded 718 lbs. grain per acre.

## (f) Sugarcane.

During the year two acres of cane of various varieties were grown at the farm, the bulk of which was disposed of for seed. Experimental crushings from various varieties sown under different conditions as under were carried out from which it will be seen that as usual sowing in trenches has produced a higher outturn than flat sowing :—

Variety.	Area cut.	Percentage of			Produce of gar per acre.	Remarks.
		Juice.	Gur.	Gur.		
		Cane.	Juice.	Cane.		
S. 39	Acres. 1/20 ...	60.0	16.5	9.9	Md. sr. 53.20	S. 39 and S. 50 sown in trenches, manured with cattle manure at 800 mds. and castor seed cake at 15 mds. per acre, Watered 6 times S. 48, A. 42 and Chin sown flat, manured with farmyard manure at 250 mds. per acre, irrigated 6 times. Sown flat in lines 2 feet apart without manure. Irrigated 4 times.
S. 48	1/20 ...	57.3	16.5	9.5	37.0	
S. 50	1/20 ...	67.6	15.6	10.5	60.0	
A. 42	1/80 ...	50.0	17.5	8.7	35.0	
Chin Ukh	1/80 ...	42.2	10.1	8.8	40.0	
Matua Ukh	1/40 ...	55.1	16.9	9.3	44.20	

## (g) Juar.

One acre each of Cawnpore Dodania and Andhri Juar were grown for comparison and yielded respectively 617 and 292 lb. of grain. The results are not comparable, however, as the portion of the field sown with Andhri juar was very poor.

## (h) Bajra.

Awned and Sitapur Rohtak bajra grown for comparison on .7 acre plots yielded respectively 475 and 346 lbs. of grain per acre. In 1921 these varieties yielded 1,070 lbs. and 889 lbs. grain per acre. The low yield during the current year is due to damage by rain.

## (i) Groundnut.

Big Japanese and Virginia bunch varieties were grown for comparison.

Variety.	Outturn per acre of dry nuts.	Remarks.
Virginia bunch	832 lbs.	Sown at 30 seeds per acre in lines 2 feet apart. Harvested, 22nd November, 1922.
Big Japanese	995 lbs.	Sown at 30 seeds per acre in lines 2 feet apart. No irrigation. Harvested, 22nd December, 1922.

In the previous year Virginia bunch yielded 915 lbs. and big Japanese 964 lbs. dry nuts per acre.

## (j) Green fodder.

Half an acre of lucerne grown for green fodder yielded respectively 228 maunds, 174 maunds and 164 maunds green fodder at the first, second and third cuttings.

APPENDIX A.

*Character of the season.*

On the 22nd of June, 1922, there was a fall of rain of about two inches which enabled the early kharif crops to be sown but the major part of the rain occurred during the last fortnight of July and the first week of August. Arhar and juar crops and cotton were damaged to some extent during July and August on account of these continuous rains and a certain amount of damage was experienced from frost during the months of December and January, the arhar and sugarcane crops being affected. The cotton crop was attacked by leaf rollers which, in conjunction with the heavy rain, lessened the outturn. The rabi crop was sown without palewa, but winter rains were deficient.

## APPENDIX B.

*Statement showing rainfall at the district farm, Mainpuri.*

Month.	First fortnight.	Second fortnight.	Monthly total.
	Inches.	Inches.	Inches.
June ... ..	1·03	2·06	3·09
July ... ..	2·36	13·82	15·18
August ... ..	6·54	3·78	10·32
September ... ..	1·63	1·50	3·13
October ... ..	...	...	...
November ... ..	...	...	..
December ... ..	·10	·23	·33
January ... ..	...	...	...
February ... ..	...	·88	·88
March ... ..	...	...	...
April ... ..	...	...	...
May ... ..	·13	·79	·92
	11·79	22·06	33·85



**VII.—JAITPUR FARM, DISTRICT HAMIRPUR.****CHAPTER I.****SITUATION AND AREA.**

This farm is situated in district Hamirpur near Belatal railway station on Jhansi-Manikpur section of the Great Indian Peninsula Railway.

Started in 1921 the farm at present consists of 30 acres, 27 of which are under cultivation. The farm is irrigated to a limited extent by the Belatal tank canal and also by one small well. The soil is parwa-kabar and much run down, but with proper manuring and careful cropping should eventually prove suitable for the growth of all local crops. Laying out, levelling and fencing work is now being taken in hand.

**CHAPTER II.****(a) Wheat.**

5.05 acres Pusa 12 wheat grown for seed yielded 600 lbs. grain and 869 lbs. straw per acre : and 11.69 acres Pusa 4 yielded 474 lbs. grain and 683 lbs. straw per acre. The above yields are poor. A small area of barley grown for seed production yielded 777 lbs. grain and 822 lbs. straw per acre.

**(b) Sugarcane.**

1.97 acres of Shahjahanpur cane no. 50 grown for outturn yielded 18,270 lbs. stripped cane per acre and a small area of S.39 variety yielded 20,917 lbs. cane per acre.

**(c) Cotton.**

The following yields of J. N. 1 cotton grown for outturn were obtained :—

*Yield in lbs. per acre.*

Variety.	Area.	Yield of kapas.	Remarks.
J. N. 1 ... ..	Acres. 1.50	246 lbs.	Sown in lines behind desi plough at 16 lbs. seed per acre.
J. N. 1 ... ..	.50	146 lbs.	

The yield is poor owing to excessive rain.

**(d) Til.**

A small area of this crop was grown for seed and an average outturn of 151 lbs. seed per acre was obtained.

**(e) Jaunpur maize and Virginia groundnut.**

A small area was sown with Jaunpur maize and Virginia groundnut in alternate lines. The maize was cut on 20th September, 1922, and groundnut dug on 25th December, 1922. The groundnut received one watering on 7th November, 1922.

Outturn maize 820 lbs. grain per acre. Groundnut 640 lbs. nuts per acre.

**(f) Fodder crops.**

Five acres of juar was sown for fodder but failed owing to excessive rain and was ploughed in in preparation for rabi crop.

**(g) Arhar.**

.65 acre arhar sown for seed production similarly failed.

## VIII.—DISTRICT WORK.

### (a) Wheat.

During the year the distribution of Pusa 4 and Pusa 12 wheats was continued on the system of *sawar* in kind instead of on a cash basis. The trials of the new varieties of Pusa wheats were completed and it has been satisfactorily ascertained that Pusa 54, a bearded variety, is likely to prove most useful in this circle. This variety will, therefore, be propagated on a larger scale on Government farms for distribution where a bearded wheat is desired.

### (b) Cotton.

It has been decided to concentrate on the propagation and distribution of J. N. 1 cotton seed and with this end in view practically the whole available area at the Government seed farm, Kalianpur, has been devoted to seed production of this variety. The Public Works department Rest House at Mandhana has been acquired for a buying centre and arrangements made with a private firm in Cawnpore to purchase the kapas of this variety at a premium. In this way it is hoped to work up a compact area of the variety round about Mandhana.

### (c) Sugarcane.

The distribution of Shahjahanpur varieties of cane for seed was continued from the Government farms at Cawnpore, Etawah, Mainpuri, Hardoi, Atarra and Jaitpur. These varieties are now well established and known to cultivators and zamindars and there is a good demand for all the cane produced on Government farms for seed.

For the amounts of seed distributed, implements sold, estimated area under improved crops and private farms in the circle and statistics of demonstration work done the Administration Report of the department should be consulted.

### (d) Jute.

It has been conclusively proved that the Ganjar areas of Sitapur and Kheri districts are suitable for this crop, but at present the chief difficulty in the way of its more universal adoption is the lack of a market for the fibre produced. It is possible to sell this fibre to the Bengal jute mills but the freight on such heavy and bulky produce does away with the profits. Negotiations are proceeding with the Fibre Expert to the Government of Bengal to endeavour to arrange for a buyer to visit the jute area at the next harvest time to buy up the produce. Nevertheless, the area under this crop has been largely increased and has risen from 97 to 204 acres. During the season 17 maunds of seed was distributed. The crop is being grown by some 800 separate cultivators. Some of the best seed was purchased by the Fibre Expert, Bengal, and the fibre produce disposed of locally.

### (e) Ravine blocks.

The ravine reclamation blocks in district Jalaun previously in the charge of this department have been handed over to the Forest department together with the buildings at the Orai farm.

**(f) Agricultural shows.**

The following agricultural shows were held in the circle during the year. Exhibits of crops and implements with assistants to demonstrate and explain their uses were sent in nearly all cases. Pamphlets on agricultural subjects printed in the Vernacular were also distributed free to those of the public who wished for them.

Name.	Date.
1. Chitrakot (district Banda)	... 19—21st October, 1922.
2. Sheorajpur (Fatehpur) ...	... 3rd November, 1922.
3. Etawah ...	... 13—20th November, 1922.
4. Patara (Cawnpore) ...	... 19—24th November, 1922.
5. Takia (district Unao) ...	... 6—11th December, 1922.
6. Shahpur (Sitapur) ...	... 5—10th December, 1922.
7. Gauria Kalan (Unao) ...	... 20—25th December, 1922.
8. Kotra (Sitapur) ...	... 24—28th December, 1922.
9. Nimgaon (Kheri) ...	... 25—29th December, 1922.
10. Makanpur (Cawnpore) ...	... 15—29th January, 1923.
11. Roni (Jhansi) ...	... 15th January, 1923.
12. Mainpuri ...	... 20—26th March, 1923.
13. Fatehpur (Islamia school)	... 16—18th March, 1923.
14. Jahanabad (Fatehpur) ...	... 31st May, 1923.

*Indian States.*

- |   |                            |
|---|----------------------------|
| 1. Govind Fair, Datia State                                   | ... 11—18th January, 1923. |
| 2. Dileep Agricultural and Industrial Exhibition, Sailana ... | ... 22nd February, 1923.   |

**(g) Fodder storage.**

During the year the fodder storage experiments at Cawnpore, Hardoi and Etawah farms were continued and a further supply laid down. The object of the experiments is explained in the Departmental Administration Report for 1921-22.

**(h) Court of Wards estates and Co-operative Banks and Societies.**

The following statement shows the amount of seed distributed by Court of Wards estates and Co-operative Banks and Societies in the circle during 1922-23.

*Statement showing the amount of seed distributed by Court of Wards estates and Co-operative Banks and Societies, 1922-23.*

Name.	Pusa 12 wheat.	Desi wheat.	Pusa 110 wheat.	Pusa gram.	Desi gram.	Barley.	American cotton.	J. N. 1 cotton.	Juar.	Rice.	Early arhar.	Maize.	Bajra.	Shubjahanpur caues.
	Ms. s. c.	Ms. s. c.	Ms. s. c.	Ms. s. c.	Ms. s. c.	Ms. s. c.	Ms. s. c.	Ms. s. c.	Ms. s. c.	Ms. s. c.	Ms. s. c.	Ms. s. c.	Ms. s. c.	Ms. s. c.
Hardoi Agricultural Supply Society.	915 27 12	...	...	...	...	...	...	18 30 0	4 15 8	...	2 33 0	15 15 0	0 24 0	2793 23 8
Central Co-operative Bank, Sandila.	309 0 0	...	...	0 25 0	...	...	...	22 32 0	...	...	...	...	...	...
Court of Wards estate, Sitapur.	807 3 4	...	...	897 6 0	...	...	...	...	...	...	...	...	...	For 136 acres,
Harehandpur Court of Wards estates, Euwah.	240 0 0	...	...	11 33 4	...	...	30 15 0	...	4 9 0	2 0 0	...	...	...	..
Mainpuri Agricultural Supply Society.	220 7 10	93 9 6	...	...	76 12 4	...	...	...	...	...	...	...	...	...
Jaerans Central Co-operative Bank, Mainpuri.	107 25 0	231 34 8	1 29 0	0 23 0	122 6 0	216 22 8	...	...	...	...	...	...	...	...
Court of Wards, Jaloun (Rampura).	...	...	...	...	...	...	...	...	...	...	...	...	...	..
<b>Total ...</b>	<b>2,590 23 10</b>	<b>328 3 14</b>	<b>1 29 0</b>	<b>410 12 4</b>	<b>198 18 4</b>	<b>216 22 8</b>	<b>30 15 0</b>	<b>41 22 0</b>	<b>8 24 8</b>	<b>2 0 0</b>	<b>2 33 0</b>	<b>15 15 0</b>	<b>0 24 0</b>	<b>For 180.4 acres.</b>

**REPORT**  
ON THE  
**AGRICULTURAL STATIONS**  
OF  
**CENTRAL CIRCLE, CAWNPORE,**  
**FOR THE YEAR 1923-24.**



**ALLAHABAD:**  
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FROM

G. CLARKE, Esq., M.L.C.,  
OFFICIATING DIRECTOR OF AGRICULTURE,  
UNITED PROVINCES,

TO

THE SECRETARY TO GOVERNMENT,  
UNITED PROVINCES,  
AGRICULTURE DEPARTMENT, ALLAHABAD.

*Dated Lucknow, the 20th August, 1924.*

SIR,

I HAVE the honour to submit the report on the Agricultural Stations of Central Circle, Cawnpore, for the year 1923-24.

The report has been drawn up by T. R. Low, Esq., Deputy Director of Agriculture, Central Circle, Cawnpore.

I have the honour to be,

SIR,

Your most obedient servant,

G. CLARKE,

*Director of Agriculture,  
United Provinces.*

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### GLOSSARY OF VERNACULAR TERMS USED.

Kapas ...	...	...	=	Seed cotton.
Bhusa ...	...	...	=	Chopped and crushed straw.
Maund ...	...	...	=	82·3 lbs.
Juar ...	...	...	=	<i>Sorghum vulgare</i> .
Bajra ...	...	...	=	<i>Pennisetium typhoideum</i> .
Guar ...	...	...	=	<i>Cyamopsis psoraloides</i> .
Gram (vernacular chana)	...	...	=	<i>Cicer arietium</i> .
Mahua ...	...	...	=	<i>Bassia latifolia</i> .
Kesari ...	...	...	=	<i>Lathyrus sativus</i> .
Berseem...	...	...	=	Egyptian clover ( <i>Trifolium alexandrinum</i> ).
Sanai (Sann hemp) ...	...	...	=	( <i>Crotolaria Juncea</i> ).
Mung ...	...	...	=	<i>Phaseolus mungo</i> .
Urd ...	...	...	=	<i>Phaseolus radiatus</i> .
Arhar ...	...	...	=	Pigeon pea ( <i>Cajanus indicus</i> ).
Palewa ...	...	...	=	Irrigation (flooding) followed by ploughing prior to sowing.
Rabi ...	...	...	=	Winter crops.
Kharif ...	...	...	=	Summer crops.

## Report of the Agricultural Stations of the Central Circle for the year 1923-24.

The Central Circle, with which is included the Bundelkhand Circle not yet separated off, consists of the following districts and has the following Government farms:—

District.	Farm.	Area in acres.
Cawnpore .. .. .	Government Experimental Station ..	71·0
.. .. .	Kalyanpur Seed Farm ..	262·77
Allahabad .. .. .	.. .. .	..
Fatehpur .. .. .	.. .. .	..
Jhansi .. .. .	.. .. .	..
Hamirpur .. .. .	Belatal Farm .. .. .	30·62
Banda .. .. .	Atara Farm .. .. .	171·40
Jalaun .. .. .	.. .. .	..
Unao .. .. .	.. .. .	..
Sitapur .. .. .	.. .. .	..
Kheri .. .. .	.. .. .	..
Hardoi .. .. .	Hardoi Farm .. .. .	40·00
Etawah .. .. .	Etawah Farm .. .. .	61·35
Mainpuri .. .. .	Mainpuri Farm .. .. .	52·81
Farrukhabad .. .. .	.. .. .	..

The detailed results obtained on these farms during the year follow. For financial results the Administration Report of the department should be consulted.

### I.—CAWNPORE EXPERIMENTAL STATION.

#### CHAPTER I.

##### (a) Situation, area and soils.

The Cawnpore Agricultural Station of the Central Circle includes the Experimental Farm and the Seed Farm, Kalyanpur. On the latter farm certain large scale trials are carried out which the restricted size of the Experimental Farm will not permit of.

The Experimental Station is situated close to Rawatpur on the Cawnpore-Achnera Railway and about 5 and 6 miles respectively from the East Indian and Oudh and Rohilkhand Railway Stations.

The whole area is irrigable from a distributary of the Lower Ganges Canal and consists of about 71 acres, 49 acres of which is cultivated. Of this area 15 acres has been taken over from the Agricultural College Farm during the current year: the remainder consists of roads, water-courses, tanks, farm buildings etc. This farm is the oldest in the department and is very uneconomical to work being badly laid out and of a shape which gives an extremely long perimeter in proportion to its area.

The cultivated area of the seed farm, Kalyanpur, during the year under report was 228·70 acres. The terracing, draining and levelling of this area has been completed and it is all now in good order although it will be some years before the whole area is uniform.

From an economic point of view this farm is at a disadvantage in having to produce the seed of standard crops such as wheat and cotton for distribution under conditions of competition for labour with factories being situated as it is near a large manufacturing centre.

## (b) Wheat.

The wheat standard series plots which have been unmanured since 1913 produced an average of 860 lbs. grain and 1,525 lbs. straw per acre. The previous treatment of these plots can be seen by consulting back reports of the Cawnpore Experimental Farm.

In addition to the above at the Cawnpore Farm 9.72 acres of Pusa 12 was grown for seed production. Of this 3.22 acres was manured with mustard cake equal to 30 lbs. nitrogen per acre and yielded 1,506 lbs. grain per acre while 6.5 acres unmanured yielded 1,384 lbs. grain per acre. All plots received two irrigations and were sown with Kell's Seed Drill at a seed rate in most cases of 85 lbs. per acre. At the Seed Farm, Kalyanpur, the following wheat was grown for seed production :—

Average outturn in maunds per acre.

Variety.				Area in acres.	Grain.	Straw.
Pusa 12	..	..	..	61.49	18.61	38.33
" 4	..	..	..	18.07	21.99	43.89
" 54	..	..	..	7.42	22.33	44.05

Pusa 54 the new variety grown on a larger scale for the first time this year is promising. It is a good yielder, awned and rust resistant the only point in doubt being whether it is sufficiently early maturing for a season when the weather turns hot early in March. Under these conditions there is a danger of the grain being caught in an unformed state and shrivelled up.

## (c) Gram.

*Varietal test of gram.*

Average yield in lbs. per acre.

Variety.	Grain.	Straw.	Remarks.
Pusa 6	1,590	1,816	All plots duplicated. Grams sown on 24th October at 80 lbs. per acre.
" 25	2,050	2,611	
Malida	1,333	1,778	Unmanured, unirrigated, previous crop wheat unmanured.
Local	2,120	2,455	

Pusa 25 and local gram have again given the best yields which is in accordance with the results obtained in previous years.

Sowing distance experiment at various seed rates with local gram.

Average yields in lbs. per acre.

Distance between rows.	Seed rate in lbs. per acre.	Grain.	Straw.	Remarks.
12"	80	2,700	3,223	All plots duplicated and sown with local gram at seed rate and distance noted. Unmanured and unirrigated, previous crop wheat unmanured.
18"	68	2,585	3,404	
24"	55	2,645	3,035	

This experiment has again given no very conclusive results but as last year sowing only 12" apart has given a slightly higher yield.

This trial will be continued next year.

*Gram seed rate experiment.*

Yield in lbs. per acre.

Local gram sown at seers per acre.	Average yield of dupli- cate plots.		Remarks.
	Grain.	Straw.	
20 .. ..	2,278	3,404	Sown 25th October behind country plough at the seed rates noted. No irrigation. Previous crop cotton un- manured. Harvested 4th April, 1924.
25 .. ..	2,333	3,630	
30 .. ..	2,903	3,924	
35 .. ..	2,335	4,171	
40 .. ..	2,260	4,274	

As in the two previous years these figures bear out the fact that a seed rate of 30—35 seers per acre produces the best yield. As this has now been proved over a series of years this experiment will be discontinued.

*Seed production.*

At the Cawnpore farm 17·87 acres of Pusa 25 gram was grown for seed production. 2·53 acres of this area sown after kharif yielded 1,726 lbs. grain per acre and 15·32 acres sown after a summer fallow yielded 2,119 lbs. gram per acre, i.e. about 21 and 26 maunds respectively.

At the seed farm, Kalyanpur, 33 acres of gram grown for seed yielded an average of over 18 maunds per acre of grain.

(d) *Sugarcane.*

At the Kalyanpur Seed Farm 8·04 acres of local and selected varieties of *pounda* were grown for seed and for sale as chewing cane and realized an average price of Rs. 820 per acre standing. This cane was all trench sown in lines 4" apart and received 40 maunds castor cake and 150 maunds cattle manure per acre. A small area of S 43 was also grown for seed the unsold residue being crushed and made into *gur*. At the Cawnpore Experimental Farm small areas of S 43 and A 42 were grown for seed production and two new varieties Co S 214 and Co S 221 obtained from the Shahjahanpur Sugarcane Research Station were tried. Of the two Co S 214 is very promising. It is a thin cane, hardy and early ripening and should become popular with cultivators if it grows well on the flat. It is being sown on the flat at the present time for trial.

(e) *Cotton.*

A comparative test of sowing cotton (J. N. 1 variety) early with irrigation and later on the rains was carried out at the Cawnpore Experimental Farm with the following results:—

(a) Sown on the 14th June, 1923, with irrigation gave 754 lbs. kapas per acre with a ginning percentage of 37 per cent.

(b) Sown on the 13th July, 1923, after the break of the rains gave 114 lbs. kapas per acre with a ginning percentage of 30·8 per cent.

The advantage of sowing cotton early with irrigation when this is possible is well demonstrated though the late sown plot suffered from the abnormally heavy rains received towards the end of the monsoon.

*Cotton for seed production.*

At the Seed Farm, Kalyanpur, the following yields of kapas in lbs. per acre were obtained :—

Variety.	Area.	Yield of kapas in lbs. per acre.
J. N. 1 .. ..	41.74	585.8
C. A. 9 .. ..	6.81	514
K. 22 .. ..	4.98	481.6

The yield of J. N. 1 cotton is considerably better than in the previous years when only 489 lbs. kapas per acre was obtained.

(f) Arhar.

Some acres of early ripening Unao arhar were put down at the Seed Farm, Kalyanpur, for seed production but the crop was badly attacked with Fusarium disease and several fields had to be burnt and ploughed up. Those remaining gave an average yield of 1,264 lbs. per acre.

At the Cawnpore Experimental Farm a comparative trial of Unao early arhar and a Saharanpur variety gave the following results :—

Yield in lbs. per acre.

Variety.	Area.	Sown.	Harvested.	Grain.	Straw.
Unao early ..	3/7 acre ..	20th July, 1923, with Cole.	14th December, 1923.	1,206	4,284
Saharanpur ..	3/7 .. ..	Planted in rows 2' apart at 30 lbs. per acre.	25th January, 1924.	746	7,553

A small white arhar much appreciated in the local market was also tried. It yielded 2,532 lbs. of grain per acre, a very good outturn. This variety will be tried again next year. There is already a considerable demand for the seed of this variety.

(g) Peas.

3.32 acres of white peas grown for seed production at the Kalyanpur seed farm yielded 11.37 maunds grain per acre and 5.40 maunds straw.

(h) Potatoes.

At the Seed Farm 4.34 acres *phulwa* potatoes grown for outturn yielded 83.61 maunds of tubers per acre.

(i) Green Fodder.

The following green fodder was grown at the Kalyanpur and Cawnpore Farms for bullock feed.

*Carwarpore Farm.*

Crop.				Area.	Outturn in lbs. per acre.
Maize	..	..	..	1.28 acres	16,071
Juar	..	..	..	2.11 "	20,694
Oats	..	..	..	.60 "	14,892

*Kalyanpur Farm.*

Crop.				Area.	Outturn in lbs. per acre.
Juar and Guar mixed	..	..	..	13.67	22,254
Lucerne	..	..	..	2.79	15,261
Oats	..	..	..	2.91	15,752
Peas	..	..	..	.64	9,097

## CHAPTER II.

## MISCELLANEOUS EXPERIMENTS.

## I.—Cultivation experiment.

In continuation of the experiment commenced last year to ascertain what increase in yield, if any, was obtained in the wheat crop by deep ploughing with inversion in comparison with ordinary ploughing with the desi plough it was found as was to be expected that the results are distinctly in favour of soil inversion so much so that shallow ploughing with inversion has produced a larger yield than deep ploughing without inversion. It would appear from this that inversion is a more important factor than depth. To finally substantiate this conclusion, however, the experiment must be continued. The actual results obtained are given below :—

Yield in lbs. per acre.

Treatment.	Grain.	Straw.	Remarks.
Deep ploughing with inversion. Iron plough.	1,410	2,330	All plots sown with Pusa 12 with Kell's Drill. 5 deep ploughings with Punjab plough 7—5" deep.
Deep ploughing without inversion. Country plough.	1,012	1,722	5 deep ploughings with Egyptian plough 7—5" deep.
Shallow ploughing with inversion. Iron plough.	1,235	2,157	5 shallow ploughings. 5—4" deep. Punjab plough.
Shallow ploughing without inversion. Iron plough.	845	1,427	5 shallow ploughings. 5—4" deep. Egyptian plough.

## II.—Comparison of the relative manurial effects of various cakes on potatoes.

Manure applied to give 100 lbs. nitrogen per acre.	Average yield of tubers in lbs. per acre, when manure was applied direct to potato crop.	Average yield of tubers in lbs. per acre when manure was applied to previous crop of maize.
Mahwa cake .. .. .	7,005	4,417
Poppy " .. .. .	10,635	4,255
Castor " .. .. .	8,525	3,895
No manure .. .. .	5,415	3,097

As last year poppy cake has given the best actual results. The cost of the manure per acre was—

Mahwa cake .. .. .	Rs. 87
Poppy cake .. .. .	51
Castor cake .. .. .	73

Taking these figures into consideration poppy cake gives the best result with 208 lbs. potatoes per rupee expended on manure with Mahwa cake next with 189 lbs. potatoes per rupee expended on manure. It is unfortunate that the supply of poppy cake is likely in the future rather to diminish than to increase.

### APPENDIX A.

#### *Character of the season.*

The rainfall at Cawnpore Farm during the year was above the normal amounting to 51.79 inches. The monsoon set in late and the kharif sowings were delayed thereby. The rainfall was continuous from the end of June to the beginning of September. A fortnight's break followed when it again came on heavily and lasted up to the end of September. This last burst was so severe that the tanks both inside and outside the farm overflowed into many of the fields and also into the homestead resulting in a diminished yield of kharif crops, as weeding and hoeing could not be carried out at the proper time. The fallow fields which were thus flooded yielded up to the average in the rabi clearly showing the bad effect of water stagnation, and lack of monsoon cultivation which was prevented on account of the rain. The season on the whole was satisfactory which is reflected in the yields of the majority of the crops.

## APPENDIX B.

Statement showing daily rainfall at the Government Experimental Farm, Cawnpore, for the year 1923-24.

Month.	Date.	Rainfall in inches.	Fort-nightly total.	Month.	Date.	Rainfall in inches.	Fort-nightly total.	
June, 1923 ..	4th	0·26	0·26	August, 1923 ..	20th	0·07		
	21st	0·05			21st	0·07		
July, 1923 ..	25th	0·15	0·57		22nd	1·80		
	29th	0·37		23rd	0·03			
	2nd	0·06		26th	0·06			
	3rd	0·03		29th	0·16			
		6th	0·21	15·16	30th	0·76		
		8th	0·54		31st	5·83		
		13th	0·69		September, 1923	1st	0·12	
		15th	0·86			2nd	0·14	
		16th	2·15		1·89	15th	0·20	0·46
		18th	1·19			21st	3·11	
		20th	1·06			22nd	4·75	
		23rd	0·89			23rd	0·11	
		24th	0·16		6·85	24th	0·08	
		25th	0·18			25th	0·22	
	26th	0·39	October, 1923 ..	30th		1·78	10·00	
	27th	0·03		1st		4·02		
	28th	0·09	2nd	0·67		8·82		
	29th	0·49	3rd	4·13				
	30th	0·18	November, 1923	30th		0·08	0·08	
	31st	0·54	December, 1923	3rd		0·07		
August, 1923 ..	1st	0·12	6·29			4th	0·44	0·51
	4th	1·13		25th		0·18	0·18	
	5th	1·88		January, 1924 ..	4th	0·03		
	6th	2·17			5th	0·03		
	7th	0·09		February, 1924..	6th	0·13	0·19	
	8th	0·73			4th	0·13	0·13	
	10th	0·04		May, 1924 ..	3rd	0·03		
	11th	0·12			14th	0·04		0·07
	12th	0·01		6·29	18th	0·03		
	16th	1·89			21st	0·23		
	17th	0·31			22nd	0·07	0·33	
	19th	4·18						
					Total ..			51·79



## APPENDIX C.

*Ten years' monsoon rainfall, Cawnpore Experimental Farm,  
1914—1923.*

Period.		1923.	1922.	1921.	1920.	1919.	1918.	1917.	1916.	1915.	1914.	Aver- age.
June	{ 1st half..	·26	·74	·49	..	·13	·82	·98	5·76	·01	·40	·96
	{ 2nd " ..	·57	·96	10·17	1·60	..	·91	2·36	7·02	3·85	..	2·74
July	{ 1st " ..	1·89	5·80	·87	1·50	6·14	1·03	2·55	5·14	3·57	6·10	3·41
	{ 2nd " ..	6·85	5·32	3·05	12·00	3·43	·43	8·10	9·20	5·84	8·83	5·81
August	{ 1st " ..	6·29	12·94	10·05	2·49	3·62	·01	4·60	4·57	4·46	3·63	5·77
	{ 2nd " ..	15·16	7·79	13·67	·02	3·55	5·30	1·96	4·41	17·93	2·30	7·21
September	{ 1st " ..	·46	4·85	5·53	·11	5·29	1·23	3·43	1·36	12·05	3·55	3·80
	{ 2nd " ..	10·00	2·84	·76	·03	·42	..	7·05	3·32	3·31	3·79	3·65
October	{ 1st " ..	8·82	..	..	..	·89	..	·02	1·93	1·65	..	1·33
	{ 2nd " ..	..	..	..	..	..	..	2·21	..	..	..	·22
Total		50·30	41·24	44·08	17·75	28·52	9·78	33·31	42·71	57·67	23·60	34·90

## APPENDIX D.

*Statement showing temperature at the Government Experimental Farm,  
Cawnpore, during the year 1923-24.*

Month.	Fortnightly mean temperature.		S a m.	For fortnight.		
	Maximum.	Minimum.		Maximum.	Minimum.	
June, 1923	1st half	111	87	96	114	74
	2nd "	105	85	91	110	77
July "	1st "	94	80	85	101	74
	2nd "	91	78	82	96	75
August "	1st "	88	78	81	98	76
	2nd "	91	77	82	95	74
September "	1st "	94	77	83	100	75
	2nd "	92	75	80	97	72
October "	1st "	90	68	77	94	61
	2nd "	92	62	74	95	58
November "	1st "	88	58	66	92	49
	2nd "	88	52	62	86	46
December "	1st "	76	51	57	83	47
	2nd "	76	47	52	80	40
January, 1924	1st "	72	47	51	75	42
	2nd "	74	45	51	82	41
February "	1st "	77	51	56	80	45
	2nd "	84	51	59	89	43
March "	1st "	92	59	69	100	51
	2nd "	97	62	74	107	56
April "	1st "	100	70	82	111	64
	2nd "	106	72	86	111	65
May "	1st "	101	71	85	109	66
	2nd "	104	76	83	110	69

( 10 )

APPENDIX E.

*Drain gauges.*

DURING the year under report it was not possible to obtain a complete record of the drainage from the set of drain gauges at the farm. In the latter half of September and early October very heavy rain fell which resulted in a flood on the farm and in the filling up of the underground chambers containing the percolation tables by surface water. Flood water entered the percolation drains and mixed with actual percolated rainfall ; the drainings were, therefore, worthless for analysis.

Quantity and composition of drain gauge waters, monsoon, 1923.

Period.	Rain in inches.	No. 1, 6' gauge.			No. 2, 6' gauge.			No. 3, 9' gauge.			No. 4, 9' gauge.			Remarks.
		Drainage in inches.	Nitric nitrogen.		Drainage in inches.	Nitric nitrogen.		Drainage in inches.	Nitric nitrogen.		Drainage in inches.	Nitric nitrogen.		
			Parts per million.	Pounds per acre.		Parts per million.	Pounds per acre.		Parts per million.	Pounds per acre.		Parts per million.	Pounds per acre.	
June 1st to 15th ..	0.26	..	..	..	..	..	..	..	..	..	..	..	..	
June 16th to 30th ..	0.57	..	..	..	..	..	..	..	..	..	..	..	..	
July 1st to 15th ..	1.89	..	..	..	..	..	..	..	..	..	..	..	..	
July 16th to 31st ..	6.86	..	..	..	..	..	..	..	..	..	..	..	..	
August 1st to 15th ..	6.29	8.861	8.508	2.675	1.499	2.848	0.799	4.103	9.636	9.158	1.788	11.128	4.515	Gauge no. IV leaked for 8 days. Gauge no. III leaked for 8 days.
August 16th to 31st..	15.16	6.874	6.816	9.136	6.839	5.997	9.806	6.657	2.196	3.227	10.835	2.936	5.479	
September 1st to 15th	0.46	0.863	7.237	1.418	1.385	4.611	1.449	0.656	2.036	0.303	0.525	1.899	0.166	
September 16th to 30th.	10.000	4.672	3.403	3.613	4.613	1.991	1.969	5.593	1.471	1.847	4.948	1.241	1.393	
October 1st to 15th..	8.820	..	..	..	..	..	..	..	..	..	..	..	..	
Total ..	50.30	15.270	20.469	16.842	14.336	14.947	13.533	16.949	15.479	14.535	17.696	15.104	11.553	

## II.—ATABA FARM, DISTRICT BANDA.

### CHAPTER I.

#### SITUATION, AREA AND SOILS.

This farm, area 171 acres, is situated on the Ken Canal about half a mile from Atara station on the Manikpur-Jhansi branch of the Great Indian Peninsula Railway and is 21 miles by road from Banda. The soil is parwa and is fairly typical of the tract surrounding the farm. With irrigation it is suitable for all crops; without irrigation it is suitable for wheat in favourable years and for juar in the *kharif*. A small portion of the farm is suitable for rice. Owing to the difficulty and expense of obtaining manure consequent on the situation of this farm the yields of all crops at this farm are low as compared with those obtained on Government farms in the Doab but during the last two years the running expenses have been greatly reduced.

### CHAPTER II.

#### (a) Wheat.

69.21 acres of Pusa 4 wheat grown for seed production yielded an average of 791 lbs. grain and 1,558 lbs. straw per acre. This is not a particularly satisfactory yield.

#### (b) Barley.

A small area of barley yielded 648 lbs. of grain per acre and 9.39 acres peas and barley mixed grown on poor land yielded 102 lbs. grain and 527 lbs. straw per acre.

#### (c) Gram.

23 acres of local gram grown for seed production yielded 723 lbs. grain per acre.

Pusa 6, 17, 18, and 25 varieties of gram were also tried on small areas for comparison. Of these, Pusa 18 proved the best yielder but is not on the whole so good as the local variety.

#### (d) Rice.

In continuation of trials carried out in previous years the following varieties of rice were again sown over about 5 acres of land :—

Yield in lbs. per acre.

Variety.	Grain.	Straw.	Remarks.
Sonkarcha .. ..	1,183	4,040	Transplanted from nursery on the 29th July, 1923. One canal-irrigation on the 15th September, 1923. All plots unmanured.
Ramjawain .. ..	699	3,311	
Banko .. ..	1,440	6,752	
Parewa .. ..	2,000	4,593	
Kala Sukhdas ..	1,088	5,192	

As in previous trials, Banko and Parewa have proved the best yielders. The newly tried variety Kala Sukhdas is nothing exceptional. 3·89 acres of Parewa dhan sown broadcast for seed yielded 1,122 lbs. grain and 3,090 lbs. straw per acre. This is a considerable improvement on the yield obtained in the previous year.

## (e) Cotton.

This crop for the second year in succession was a total failure owing to excessive rain and had to be ploughed up. The Farm Advisory Committee have recommended that in future it should not be sown at all or, if sown, only in limited quantities.

## (f) Sugarcane.

During the year under report 4·37 acres sugarcane were grown. The produce was either sold for seed or was made into gur. The results of experimental cuttings are given below :—

*Results of the sugarcane-cutting.*

Variety.	Outturn in lbs. per acre.						Remarks.
	Juice.	Gur.	Gur.	Cane.	Juice.	Gur.	
	Cane.	Juice.	Cane.				
				<i>Trench sowing.</i>			
S. 43 ..	59·59	16·78	10·00	23,557	14,040	2,955	Sown in trenches in lines 4' apart. Manured with 200 maunds dung and 80 maunds mahwa cake per acre. Five irrigations. Sown flat in lines 4' apart with same manure as above. Five irrigations.
S. 39 ..	59·88	17·27	10·84	16,495	9,877	1,705	
A. 42 ..	51·20	19·80	10·14	21,469	10,992	2,176	
Pounds ..	..	..	..	6,372	..	..	
S. 43 ..	61·20	16·93	10·36	32,332	20,092	3,403	
S. 39 ..	61·22	16·18	9·90	36,521	22,359	3,616	
A. 42 ..	54·03	19·27	10·42	24,927	13,431	2,599	

## (g) Juar.

Trials with varieties of juars were continued with following results :—  
Yields in lbs. per acre.

Variety.	Grain.	Straw.	Remarks.
Andhri ..	475	4,853	Plots were resown owing to excessive rainfall. Final sowing on 15th July, 1923. All plots harvested in the first week of December. Previous crop wheat without manure.
Ghasna ..	487	5,331	
Cawnpore Dodania.	593	5,328	

These yields are rather better than those obtained in the previous year, but as usual there is very little to choose between the three varieties.

(h) **Maize.**

A small plot of Muzaffarnagar maize grown with well-irrigation yielded 384 lbs. cobs and 636 lbs. straw. The low outturn is due to excessive rainfall.

(i) **Groundnut.**

Four acres of large Virginia groundnut grown for seed yielded 800 lbs. per acre of dry nuts. This crop also in common with the other kharif crops of the farm suffered from excessive rain.

(j) **Potatoes.**

In accordance with the recommendation of the Farm Advisory Committee 3/4 acre of potatoes grown with well-irrigation yielded 4,386 lbs. of tubers per acre.

(k) **Fodder.**

3.27 acres of juar grown for green fodder yielded 9,845 lbs. fodder per acre.

(l) **Arhar.**

Local and white varieties of arhar grown for comparison yielded as under.

Yield in lbs. per acre.

	Grain.	Straw.
Local .. ..	949	5,119
White .. ..	1,568	7,781

**APPENDIX A.**

*Character of the season.*

The monsoon set in strongly from the 3rd week of July and was practically continuous to the end of August. In consequence of this, difficulty was experienced in the sowing and weeding of the kharif crop resulting in poor outturns in the case of some crops.

Ample moisture was left in the soil by a timely fall in September and *rabi* preparation and sowing was carried through satisfactorily.

The wheat crop in general promised well but rust attacked all varieties with the exception of Pusa 4 and this coupled with lack of irrigation water caused a diminished yield.

## APPENDIX B.

Statement showing the daily rainfall at the Alara farm, district Banda, for 1923-24.

Month.	Date.	Rain-fall in inches.	Fort-nightly total.	Month.	Date.	Rain-fall in inches.	Fort-nightly total.
June, 1923 ..	21st	0.30	0.30	August, 1923 ..	16th	1.45	
July, 1923 ..	2nd	0.84			17th	0.06	
	6th	0.15			18th	1.40	
	7th	2.08			19th	0.10	
	12th	0.09			20th	1.37	
	13th	1.10	4.26		21st	0.73	
	16th	0.50			22nd	0.58	
	17th	0.31			23rd	0.25	
	18th	0.19			24th	1.37	
	19th	0.03			25th	0.22	
	20th	0.34			26th	0.13	
	24th	1.24			29th	0.15	
	26th	1.73			30th	3.37	
	27th	1.94			31st	1.71	12.89
	28th	0.55		September, 1923 ..	1st	0.19	0.19
	29th	0.31			21st	1.16	
	30th	3.32			22nd	0.26	
	31st	0.07	11.13		23rd	0.96	
August, 1923..	3rd	0.23			24th	1.31	
	5th	3.00			25th	0.17	
	6th	0.90			29th	0.18	
	7th	0.53			30th	2.47	6.51
	8th	0.77		October, 1923 ..	1st	0.27	0.27
	9th	0.02		December, 1923 ..	28th	0.33	0.33
	11th	0.35		January, 1924 ..	6th	0.33	0.33
	12th	1.72			28th	0.32	0.32
	13th	0.40		February, 1924 ..	3rd	0.08	..
	14th	0.22	8.24		4th	0.03	0.11
				Total ..	..	..	44.83



## III.—ETAWAH FARM.

## CHAPTER I.

## SITUATION, AREA, AND SOILS.

This farm occupies about 61 acres of *nazul* land near the Etawah civil station and is primarily intended for demonstration and seed-supply and is also used for variety testing and local experiment. The whole area is irrigable from the Etawah distributary, Bhognipur branch, Lower Ganges Canal, and the soil is fairly typical of the district. The farm is managed departmentally. Owing to its situation within municipal limits this farm has, now under the revised rates, to bear very heavy irrigation charges the expense of which cannot be counterbalanced by the growth of fruit and vegetable, the main staples of the district, such as wheat, cotton, and sugarcane only being grown. This matter has been brought to the notice of the Hon'ble Minister and the Farm Advisory Committee and it is hoped that an exception to these rules may be made in the case of this farm.

During the year this farm again paid its way and yielded a small profit to Government.

## CHAPTER II.

## (a) Wheat.

16·10 acres Pusa 12 wheat grown for seed-supply yielded an average of 18 maunds 19 seers grain and 36 maunds 28 seers straw per acre. This crop again suffered some damage from wild pig.

## (b) Gram.

Four varieties of gram were grown for seed-supply, Pusa 17, 18, 25, and local gram. The total area sown was 7·5 acres and the average yield 20 maunds 25 seers of grain per acre. Of the four varieties Pusa 18 gave the highest yield.

## (c) Peas.

Five acres of peas grown *dofasli* after cotton yielded an average of 633 lbs. per acre.

## (d) Bejhra (peas and barley).

12·15 acres of this crop was grown, some being fed green to bullocks, the remainder being allowed to seed yielded 6 maunds 26 seers grain per acre.

## (e) Sugarcane.

The following results were obtained on the farm during the current year. The cane produced was, as last year, all sold either for seed or for crushing purposes. The results obtained are well up to the average of this farm :—

Area in acres.	Variety.	Yield of cane in lbs. per acre.	Remarks.
·60	S 48	59,750	} Sown after wheat all in trenches 4' apart.
·60	S 50	51,616	
·50	S 39	70,500	
·50	S 48	61,560	} Sown on flat after wheat crop.
·125	A 42	38,400	
·125	Matna	40,720	

(f) Cotton.

This year proved considerably more favourable for the cotton crop. 7.0 acres J. N. 1 cotton grown for seed-supply yielded 687 lbs kapas per acre. This is a very fair yield and above the average usually obtained at this farm.

(g) Arhar.

One acre of early Unao arhar yielded 1,490 lbs. grain and 1,678 lbs. straw per acre.

(h) Maize.

1.50 acres Jaunpur maize yielded 699 lbs. grain and 1,948 lbs. straw per acre.

(i) Bajra.

3.50 acres awned bajra yielded 194 lbs. grain and 2,763 lbs. straw per acre. Both this crop and the maize crop were damaged by pigs and stray cattle; hence the poor yields.

(j) Juar for grain and fodder production.

1½ acres Dodania Juar grown for green fodder yielded 28,509 lbs. per acre. 2.3 acres grown for grain yielded an average of 335 lbs. grain per acre and 10,860 lbs. dry fodder per acre. The crop was damaged by pigs.

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APPENDIX A.

*Character of the season.*

On the whole the agricultural year under report has been normal and satisfactory. Monsoon conditions were fully established by the end of July, and continued strongly throughout August. During the latter half of September, the rains were abnormally heavy and continued up to the first week of October. This rain was harmful to the flowering cotton but afforded ample moisture for rabi sowings. - Timely rain in December was beneficial to the standing rabi and facilitated the sowings of *do-fasli* peas on a large scale.

The wheat crop in its early stages appeared very promising but continuous west winds during March, somewhat decreased the final yield. The health of the farm cattle during the year was good and no diseases either fungoid or insect appeared among the crops.

## APPENDIX B.

*Statement showing the daily rainfall at the Government District Farm, Etawah, for the year ending 31st May, 1924.*

Month and date.	Rainfall in inches.	Fort-nightly total.	Month and date.	Rainfall in inches.	Fort-nightly total.
June, 1923 17th ..	0.16		September 1923 8th ..	0.08	
" " 20th ..	0.22	0.38	" " 14th ..	0.06	0.14
July " 8th ..	0.05		" " 21st ..	2.45	
" " 12th ..	0.27		" " 22nd ..	0.73	
" " 13th ..	0.15	0.47	" " 23rd ..	6.68	
" " 18th ..	0.97		" " 24th ..	1.09	
" " 26th ..	0.18		" " 25th ..	0.18	
" " 27th ..	0.60		" " 30th ..	1.07	12.14
" " 28th ..	0.26		October " 1st ..	0.74	
" " 30th ..	0.61		" " 2nd ..	0.01	0.75
" " 31st ..	0.01	1.98	November " 30th ..	0.27	0.27
August, 1923 4th ..	1.28		December " 2nd ..	0.12	
" " 5th ..	0.44		" " 3rd ..	1.27	1.39
" " 6th ..	0.25		" " 24th ..	0.03	
" " 7th ..	0.78		" " 25th ..	0.12	0.15
" " 8th ..	1.36		January, 1924 4th ..	0.08	
" " 9th ..	0.20		" " 5th ..	0.50	
" " 10th ..	0.56		" " 5th ..	0.26	0.84
" " 11th ..	1.84	7.62	February, " 8rd ..	0.11	
" " 12th ..	0.91		" " 4th ..	0.01	
" " 16th ..	1.06		" " 11th ..	0.09	0.21
" " 17th ..	0.12				
" " 19th ..	0.80				
" " 21st ..	0.88				
" " 22nd ..	0.22				
" " 26th ..	0.01				
" " 29th ..	0.98				
" " 30th ..	0.02				
" " 31st ..	0.39	4.08	Total ..	..	30.42

## APPENDIX C,

Statement showing the mean temperature at Government District Farm, Etawah, for the year ending the 31st May, 1924.

Month.			Fortnightly mean temperature in shade.		S a m.	Remarks.
			Maximum.	Minimum.		
1.	June, 1923	1st half ..	112.8	84.4	95.1	
2.	" "	2nd " ..	107.9	88.1	91.9	
3.	July, "	1st " ..	98.8	77.8	84.4	
4.	" "	2nd " ..	95.0	76.2	81.7	
5.	August, 1923	1st " ..	88.0	74.5	79.0	
6.	" "	2nd " ..	90.2	73.3	79.1	
7.	September, 1923	1st " ..	94.0	71.8	79.9	
8.	" "	2nd " ..	89.8	70.5	76.6	
9.	October, "	1st " ..	88.0	61.9	72.6	
10.	" "	2nd " ..	90.9	57.2	71.8	
11.	November, "	1st " ..	85.9	48.0	63.2	
12.	" "	2nd " ..	81.6	46.6	55.2	
13.	December, "	1st " ..	71.8	46.0	51.2	
14.	" "	2nd " ..	73.2	42.2	48.2	
15.	January, 1924	1st " ..	67.4	42.1	47.0	
16.	" "	2nd " ..	70.9	39.6	46.1	
17.	February, "	1st " ..	73.7	45.6	51.8	
18.	" "	2nd " ..	80.0	43.1	53.5	
19.	March, "	1st " ..	90.3	51.2	64.4	
20.	" "	2nd " ..	96.9	56.5	71.5	
21.	April, "	1st " ..	100.0	62.5	79.4	
22.	" "	2nd " ..	105.6	67.8	83.2	
23.	May, "	1st " ..	104.9	68.2	83.4	
24.	" "	2nd " ..	108.0	71.8	87.8	

**IV.—HARDOI FARM.****CHAPTER I.****SITUATION, AREA, AND SOILS.**

This farm is situated near the Hardoi civil station and occupies about 40 acres of light land now irrigable from a Brownlie tube well. When taken over, the land had been badly depreciated by erosion but this has now been almost entirely remedied by draining and terracing, but it will be some years before the fields are uniform. The farm is financed by the Hardoi district board, which takes receipts and meets working expenditure, the supervising staff being provided by the department. Owing to the success of this farm, it is proposed to increase its area by some 12 acres, as this will enable profits to be increased and at the same time will only add slightly to the running charges of the farm.

The project has the approval of the United Provinces Board of Agriculture and it is hoped that the new land may be taken over in April, 1925.

**CHAPTER II.****(a) Wheat.**

4.19 acres of Pusa 12 wheat grown for seed-production yielded an average of 1,262 lbs. grain and 3,113 lbs. straw. This is a lower yield than is usually obtained on this farm but the fields were in some places badly lodged.

One acre of the new variety, Pusa 54, was grown and yielded 1,411 lbs. or 17 maunds 6 seers grain per acre. This new awned variety is already gaining popularity among the agricultural public.

**(b) Cotton.**

1.82 acres of J. N. 1 cotton grown for seed-production yielded 576 lbs. kapas per acre. This is quite a satisfactory yield and considerably better than in the previous year.

**(c) Maize.**

1.77 acres of Jaunpore maize yielded 904 lbs. grain per acre.

**(d) Juar.**

.75 acre Cawnpore Dodania Juar yielded 1,014 lbs. grain and 6,584 lbs. *karbi* per acre. This is a considerably better yield than in the previous year.

**(e) Early arhar and guar.**

Sown together 1.82 acres of this crop yielded as under:—

						Yield in lbs. per acre.
						Grain.
Early arhar	..	..	..	..	..	490
Guar	..	..	..	..	..	1,142

(f) Groundnuts.

3.83 acres of big Japanese groundnut sown for seed-production yielded 2,374 lbs. of dry nuts per acre. This is over 28 maunds per acre and is an excellent yield.

(g) Sugarcane.

The area under this crop was increased from nine to thirteen acres during the year under report. The methods of cane-growing practised on this farm and the varieties recommended are now well known in the district as is exemplified by the number of leading zamindars and cultivators who are opening farms of their own and who are taking up the cultivation of this crop on the same lines. During the gur-making season a hand-driven centrifugal gur-refining machine was demonstrated at the farm with such good results that it is hoped to purchase one permanently for the farm this year. The detailed results of the cane grown are shown below. The produce was disposed of either as raw or sold for seed or chewing purposes.

*Outturn in maunds per acre.*

Variety.	Manure.	Sowing.	Irrigations.	Previous crop.	Cane.	Rab.
S 48 ..	Farmyard manure 200 maunds per acre.	Trenches 4' apart ..	Six ..	Potato manured with farmyard manure.	Mds. srs. 989 37	Mds. srs. 125 89
S 48 ..	Farmyard manure 200 maunds plus castor cake at 10 maunds per acre.	Trenches 3½' apart ..	Five ..	Groundnuts manured with farmyard manure.	995 28	..
S 48 (ratooned)	Cake at 80 maunds per acre.	..	Five ..	S 48 cane on the flat ..	488 31	58 86
S 89 ..	Ditto ..	Flat sown 3½' apart ..	Five ..	Ditto	711 14	..
S 89 ..	Farmyard manure at 200 maunds and castor cake at 10 maunds per acre.	Trenches 3½' apart ..	Five ..	Cotton without manure	722 13	..
S 50 ..	Ditto ..	Ditto ..	Six ..	Early arhar manured with farmyard manure.	782 14	..
White paunda	Ditto ..	Trenches 4' apart ..	Eight ..	Groundnuts manured with farmyard manure.	690 9	..
Ditto ..	Farmyard manure at 200 maunds and castor cake at 20 maunds per acre.	Ditto ..	Nine ..	Early arhar ploughed in ..	684 9	..

## APPENDIX A.

*Character of the season.*

Very little rain was received in June, but from July onwards to September the rains were heavy and continuous and caused some damage to the standing maize crop and delaying the preparation of the *rabi* area. Sowings were somewhat delayed, but were carried through without *palewa*. On the whole the season has in general been satisfactory; yields from the crops have been up to the average and the farm has after paying all expenses again shown a substantial profit on the year's work.

## APPENDIX B.

*Statement showing the rainfall at the Hardoi Farm for 1923-24.*

Month and date.	Rainfall in inches.	Fort-nightly total.	Month and date.	Rainfall in inches.	Fort-nightly total.
June, 1923 4th ..	0.63	0.63	September, 1923, 2nd	0.10	
			" " 3rd	0.92	
			" " 15th	0.80	1.32
July, " 1st ..	0.30		" " 21st	2.50	
" " 8th ..	1.27		" " 22nd	1.65	
" " 12th ..	0.23		" " 23rd	1.08	
" " 13th ..	0.12		" " 24th	2.31	
" " 15th ..	0.65	2.57	" " 25th	0.24	
" " 18th ..	1.75		" " 30th	1.50	9.28
" " 20th ..	0.50		October, " 1st	1.32	
" " 24th ..	1.85		" " 2nd	1.67	
" " 25th ..	0.80		" " 3rd	0.77	3.76
" " 26th ..	0.05		Novr., " 30th	0.02	0.02
" " 27th ..	0.10	6.05	Dec., " 3rd	2.4	
August, " 1st ..	0.04		" " 4th	0.28	2.68
" " 3rd ..	0.08		" " 25th	0.06	0.06
" " 5th ..	9.10		Jan., 1924, 4th	0.16	
" " 6th ..	1.0		" " 5th	0.04	
" " 7th ..	0.05		" " 6th	0.50	0.70
" " 8th ..	0.45		Feb., " 4th	0.40	
" " 11th ..	1.81		" " 7th	0.05	0.45
" " 12th ..	0.29	12.82	March, " ..	Nil.	
" " 16th ..	0.09		April, " ..	Nil.	
" " 19th ..	1.50		May, " ..	Nil.	
" " 21st ..	0.07				
" " 22nd ..	0.34				
" " 23rd ..	4.46				
" " 24th ..	0.03				
" " 25th ..	6.24				
August, " 30th	1.85				
" " 31st	8.47	11.99			
			Total ..	..	51.33



## V.—MAINPURI DISTRICT FARM.

## CHAPTER I.

## SITUATION, AREA, AND SOILS

This farm, some 52 acres in area, is situated near the Kachehri Railway Station, Mainpuri. The soil is for the most part *bhur* shading off into a poor loam towards the south-east side of the farm. Bad *usar* patches occur in places which together with the unevenness of the soil make the results of any trials and comparisons of varieties of very little value. The farm has now been levelled and a system of cropping adopted by which it is hoped that these defects may be to some extent eradicated. A Chaudhri well with oil engine and brick irrigation channels has been installed and with the aid of this, it will doubtless be possible to place a larger area of the farm under *rabi* and thus improve the financial position.

## CHAPTER II.

## (a) Wheat.

Pusa 12 grown for seed-supply gave the following yields in lbs. per acre:—

Yields in lbs. per acre.

Area in acres.	Previous crop with manure.	Manure for the present crop.	Date of sowing.	Grain.	Bhusa.
0.30	Jaunpur maize ..	Castor seed cake manured at 5 maunds per acre.	1st November, 1923.	2757.0	2768
1.00	Ditto ..	Ditto ..	Ditto ..	1452.5	2041
1.00	Ditto ..	Ditto ..	31st October, 1923.	1650.1	2637
1.00	Sugarcane with farmyard manure at 250 maunds per acre.	Ditto ..	Ditto ..	1592.4	1884
1.00	Sanai without manure.	Ditto ..	3rd November, 1923.	1265.2	1582
0.62	Ditto ..	Ditto ..	6th November, 1923.	918.6	1412
1.80	Ditto ..	Castor seed cake manured at 3 maunds 15 seers per acre.	4th November, 1923.	2383.1	3334
1.30	Ditto ..	Castor seed cake manured at 3 maunds 30 seers per acre.	5th November, 1923.	1218.8	1146
2.00	Juar without manure.	Poudrette manured at 435 maunds per acre.	1st/2nd November, 1923.	2502.3	4421
1.80	Gram without manure.	Castor seed cake manured at 5 maunds per acre.	3rd November, 1923.	1369.2	1659

## (b) Gram.

1.80 acres Pusa 25 gram grown for seed-production yielded 1,314 lbs. grain per acre. A trial of various varieties of gram was again carried out with the following results:—

Variety.	Yield in lbs. per acre.	Remarks.
Pusa no. 6 .. .. .	885	Previous crop wheat manured with dung on 23rd October, 1923, at 50 seers per acre.
Do. 17 .. .	1,759	
Do. 13 .. .	1,955	
Do. 25 .. .	2,186	
Cawnpore yellow .. .	2,119	

This trial in conjunction with that carried out last year shows Pusa 25 variety to be a consistent yielder.

## (c) Cotton.

*Seed-production.*

.90 acre of J. N. 1 variety of cotton was sown for seed-production and yielded 460 lbs. of kapas per acre. This is about up to the average cotton crop obtained on this farm and is considerably better than last year.

*Chess Board Trial.*

This trial was again carried out with the same varieties as last year with the following results:—

Variety.	Yield per acre in seers.	Probable error.
Raya .. .. .	130	± 178
Aligarh White flower .. .	179	± 471
J. N. 1 .. .	198	± 71
K. 22 sown 1' × 2' .. .	106	± 10
K. 22 sown 18" × 2' .. .	182	± 106

*Remarks.*—All plots were sown at the rate of 10 lbs. per acre. The margin of error obtained, however, is so wide as to make the trial of very little value.

The land of this farm is, however, poor and so impregnated with *usar* patches that it is not possible to select a piece of any size of sufficient uniformity to carry out such experimental work.

## (d) Peas.

One acre of white peas grown after juar manured with pondrette yielded 1,070 lbs. grain per acre.

## (e) Maize.

2.30 acres of Jaunpore maize grown for seed-production yielded 1,025 lbs. grain per acre.

## (f) Juar.

One acre each of Cawnpore Dodania and Andhri Juar yielded 1,157 lbs. and 934 lbs. of grain per acre respectively.

## (g) Bajra.

Awned and Sitapur Rohtak bajra were again grown for comparison on  $\frac{3}{4}$  acre plots and yielded respectively 711 lbs. and 381 lbs. of grain per acre. The field where the trial was carried out was a poor *bhur* soil. Awned bajra has again proved its superiority and is to be preferred owing to its greater immunity from attack by birds.

## (h) Groundnut.

The soil of the farm is particularly suited to this crop being light and friable. The following varieties were grown for seed-production :—

Variety.	Area.	Outturn per acre in lbs. of dry nuts.	Remarks.
Big Japanese .. ..	4.80	1,075	Unmanured.
Virginia bunch .. ..	4.20	1,489	Manured poudrrette at 185 maunds per acre.

Both crops sown in lines  $2\frac{1}{2}$ ' apart at 30 seeds per acre. These yields are considerably better than those obtained in the previous year.

## (i) Sugarcane.

During the year 3.475 acres of cane of similar varieties to last year were grown. The bulk of the crop was disposed of either for seed or was crushed and the juice sold. Experimental crushing gave results as under :—

Variety of cane.	Percentage of			Produce of gur per acre.	Remarks.
	Juice.	Gur.	Gur.		
	Cane.	Juice.	Cane.		
S. 48 cane .. ..	55.5	20.9	11.6	M. s. c. 75 10 0	All cane received six irrigations.
S. 39 cane .. ..	58.1	18.8	10.9	61 30 0	S. 48 and S. 39 sown in trenches 4' apart and manured with dung at 250 maunds per acre and castor cake at 5 maunds per acre.
A. 42 cane .. ..	45.1	20.5	9.2	38 10 0	A. 42 Chin and Matna sown flat in lines $2\frac{1}{2}$ ' apart.
Chin cane .. ..	50.8	21.1	10.7	38 0 0	A. 42 received poudrrette at 70 maunds and castor cake at 5 maunds per acre. Chin and Matna poudrrette at 200 maunds per acre.
Matna cane .. ..	43.3	18.9	8.2	45 20 0	

These results are better than those obtained from the same canes in the previous year.

APPENDIX A.

*Character of the season.*

On the whole the season has been satisfactory and agricultural conditions generally favourable at this farm. The monsoon set in late necessitating *palawa* for the sowing of early *khariif* crops. During the latter part of July and during the whole of August rainfall was plentiful and continued with breaks up to middle of September enabling *rabi* cultivation and sowing to be carried out satisfactorily.

The young *rabi* crops were greatly benefited by a 2" fall of rain early in December.

No more rain fell and the rest of the season including harvest was normal. No diseases either insect or fungoid appeared during the year on this farm. Rates for agricultural labour show no marked tendency to fall but there has been a considerable fall in the prices obtained for all farm produce. The health of the farm cattle during the year has been satisfactory.

It is satisfactory to note that in practically every case the yields obtained from the standard crops on the farm have considerably exceeded those obtained in the previous year.

## APPENDIX B.

Statement showing rainfall at the district farm, Mainpuri,  
for 1923-24.

Month.				Rainfall in inches.	Monthly total.
June, 1923	..	..	1st half	..	..
			2nd "	..	..
July,	"	..	1st "	2.53	..
			2nd "	4.38	6.91
August,	"	..	1st "	8.65	..
			2nd "	7.87	11.52
September,	"	..	1st "	..	..
			2nd "	12.34	12.34
October,	"	..	1st "	1.71	..
			2nd "	..	1.71
November,	"	..	1st "	..	..
			2nd "	..	..
December,	"	..	1st "	2.85	..
			2nd "	0.08	2.88
January, 1924	..	..	1st "	0.22	..
			2nd "	..	0.22
February,	"	..	1st "	0.19	..
			2nd "	..	0.19
March,	"	..	1st "	..	..
			2nd "	..	..
April,	"	..	1st "	..	..
			2nd "	..	..
May,	"	..	1st "	0.16	..
			2nd "	0.03	0.19
Total				..	35.46

**VI.—JAITPUR FARM, DISTRICT HAMIRPUR.****CHAPTER I.****SITUATION AND AREA.**

This farm is situated in district Hamirpur near Belatal railway station on Jhansi-Manikpur section of the Great Indian Peninsula Railway.

Started in 1921, the farm at present consists of 30 acres, 27 of which are under cultivation. The farm is irrigated to a limited extent by the Belatal tank canal and also by one small well. The soil is parwa-kabar and much run down, but with proper manuring and careful cropping should eventually prove suitable for the growth of all local crops. Laying out, levelling and fencing work is now being taken in hand. Orders have been received from Government for the closure of this farm but the Hamirpur District Board are now considering the question of taking it over from the department and running it.

**CHAPTER II.****(a) Wheat.**

9.91 acres of Pusa 4 wheat grown for seed-supply yielded 569 lbs. grain per acre and 849 lbs. straw, while 4.35 acres Pusa 12 yielded 480 lbs. grain and 703 lbs. straw. This yield is very poor and it would probably be advisable to change the variety grown to some good local variety.

**(b) Barley.**

One acre of barley also grown for seed-production yielded 502 lbs. grain per acre.

**(c) Cotton.**

This crop was practically destroyed by the heavy and continuous rain. Weeding could not be carried out and the yield of kapas was negligible.

**(d) Urd.**

Two and a quarter acres of this crop grown for seed-production yielded 931 lbs. grain and 3,931 lbs. straw. The yield as those of the other *kharif* crops is poor, due to the heavy rain and consequent lack of opportunity for weeding and cultivation.

**(e) Potato.**

.04 acre of this crop yielded 4,900 lbs. tubers per acre. This is a very poor yield but the soil is not suitable for this class of crop and the yield was also decreased by the shade of trees.

**(f) Sugarcane.**

3.725 acres of cane were grown. The results are noted below :

Variety.	Outturn in lbs. per acre.		Percentages from experimental crushings.		
	Area.	Outturn.	Juice.	Gur.	Gur.
			Cane.	Juice.	Cane.
S. 50 .. ..	2.36	25,827	55.56	19.33	10.77
S. 39 .. ..	1.1	24,002	54.99	19.97	10.98
S. 50 .. ..	.25	24,584	54.21	19.72	10.69

This was the most successful crop on the farm and the results obtained are a considerable improvement on previous years and compare favourably with those obtained on other Government farms in the Circle.

**VII.—GENERAL AND DISTRICT WORK.**

On the whole the year under report has been a favourable one for the agriculturist, the *kharif* of 1923 being up to the average and the *rabi* harvest of 1924 good. The prices obtained for all agricultural produce have fallen and this has reacted unfavourably on the finances of the farms in the circle since at present the cost of labour has not fallen proportionately with the fall in the price of produce.

The question of separating the Bundelkhand division to form a separate circle is still under consideration; agricultural and clerical staff has been provided but so far no Deputy Director. It would appear desirable, if possible, to form a separate circle of this tract as soon as possible since the circle as at present constituted is large and difficult to supervise.

**(a) Committees.**

The Farm Advisory Committees recently appointed by *Government* of the Government farms of this circle have all met twice during the year with the exception of the Cawnpore Committee which has owing to the resignation of the chairman, only held one meeting. Interesting points have been raised and discussed and useful suggestions offered which have been acted upon.

In many districts of the Circle the District Board, Agricultural Sub-Committees are also active and inquiries have been received regarding suggested lines of work. Assistance has already been given by supplying seed of various varieties of crops.

**(b) Seed-distribution.***Wheat.*

There are now 23 seed stores in this circle. During the year distribution of Pusa 12 and Pusa 4 wheat has proceeded on the system of sawaii in kind which appears popular. Pusa 54, a bearded variety, has been propagated on a larger scale at the Government Seed Farm, Kalianpur, and in due course will be distributed where a bearded wheat is required. The demand for Pusa wheat is now far in excess of the supply available from Government farms. Land is now being acquired for the opening of another Departmental Seed Store in Sitapur.

*Cotton.*

The distribution of J. N. 1 cotton seed has been continued but difficulty is experienced in obtaining a large supply of pure and reliable seed without entering into extensive cotton purchase operations. The total quantity of seed that can be grown on the Government farms of this circle is only some 150 maunds which is quite inadequate.

*Sugarcane.*

The improved Shahjahanpur varieties are now well-established specially in the neighbourhood of the Hardoi Farm and distribution of cane for seed is proceeding. The natural spread of these canes apart from that grown from seed obtained from Government farms is appreciable and several of the larger zamindars and cultivators of the Hardoi district have opened private farms and are growing these canes with great success.

**(c) Demonstration of crops on the Bataii system of farming.**

During the year under report demonstration on the Bataii system was commenced in the Cawnpore district in four villages on the land of six different cultivators. Twenty-one acres of land were farmed, the system adopted being for the department and the cultivator concerned to share the total expenses of growing the crop and then halve the profits at harvest time. The actual operations of farming were in entire charge of an agricultural assistant of the department and were carried out in accordance with the methods recommended by the department. Careful accounts of every operation were kept and show that total expenditure on the 21 acres was Rs. 1,381 and the total profits Rs. 508, a return of about 35 per cent. on the capital invested. It was necessary, however, in most cases for the department to supply the capital for running expenses during the growth of the crop, the cultivator assisting with labour and bullocks.

The most successful crops proved to be sugarcane and wheat, both grown from seed supplied by the department, the profit in the former case being about Rs. 190 per acre and in the latter Rs. 50.

During this preliminary trial many obstacles have occurred and defects in the system shown themselves, but it is hoped to keep the system going as a demonstration, as there is no doubt that growing these crops on cultivators' land in constant association with them cannot fail to demonstrate to them the desirability of following the methods recommended by the department.

**(d) Jute.**

As was noted last year, the chief obstacle in the way of a more rapid spread of this crop is lack of a special market for the produce. Nevertheless owing to the manner in which it withstood the floods in the Ganjer area of Sitapur it has become popular in this district and in Kheri district and is now grown to supply fibre for local requirements in place of sanai.

**(e) Implements.**

During the year many implements have been sold direct to cultivators for cash and on taqavi. The most popular are small improved ploughs and bullock-power sugarcane-crushing mills.

For the actual figures of the various kinds of seeds distributed, implements sold, estimated area under improved crops, number of private farms in the circle, and statistics of demonstration work done the administration report of the department should be consulted.

**(f) Agricultural shows.**

The following agricultural shows were held in the circle during the year. These shows form a very valuable means of bringing the department in touch with the agricultural public. Exhibits of crops and implements with assistants to demonstrate and explain their uses are shown



and often result in implements being purchased and seed ordered on the spot :—

1923-24.

*List of Agricultural shows.*

Name.	Date.
1. Khaga, Fatehpur ... ..	3rd November, 1923.
2. Sheorajpur, Fatehpur ... ..	21st November, 1923.
3. Jahanabad, Fatehpur ... ..	10th December, 1923.
4. Chitrakot Fair (Banda) ... ..	8th, 9th, and 10th November, 1923.
5. Etawah Exhibition ... ..	3—15th December, 1923.
6. Gauria Kalan (Unao) ... ..	8—21st January, 1924.
7. Makanpur Fair, Cawnpore ... ..	3—17th February, 1924.
8. Mainpuri show ... ..	25—31st March, 1924.
9. Hardei Exhibition ... ..	20—28th February, 1924.
10. Misrikh, Sitapur ... ..	17th March, 1924.
11. Roni Fair, T. Mau, district Jhansi ... ..	14th January, 1924.
12. Rajapur, Karwi, district Banda ... ..	1—4th March, 1924.
13. Jahanabad Cattle Fair, Fatehpur ... ..	17th June, 1924.

**(g) Fodder Storage.**

This has now been discontinued. The stocks of fodder already stored will be opened according to programme and a report will be issued at the completion of the experiment.

**(h) Court of Wards and Co-operative Banks and Societies.**

The following statement shows the amount of seed distributed by Court of Wards Estates and Co-operative Banks and Societies in this Circle during 1923-24. The agricultural work of the Court of Wards estates in this circle is being gradually taken over by the Agricultural Advisor to the Balrampur Estate. He has already taken over the supervision of the Porter Farm of the Katesar Estate. *List attached.*

Statement showing distribution of Improved Seeds during 1923-24.

Name of seed.	Cawnpore.		Fatehpur.		Etawah farm.		Court of Wards farm, Harohandpur, district Etawah.		Farrukhabad.	
	Quantity.	Area.	Quantity.	Area.	Quantity.	Area.	Quantity.	Area.	Quantity.	Area.
Wheat Pusa 12 .. ..	Mds. srs. ch.		Mds. srs.		Mds. srs. ch.		Mds.		Mds. srs.	
1,962 8 0	1,726.61	490 5	450.00	526 0 0	435.0	300	240.0	160 0	128.0	
Ditto 4 .. ..	162 8 0	132.10	10 0	10.00	..	..	..	..	..	
Other improved wheats .. ..	89 28 4	34.60	..	..	5 98 0	4.5	..	..	..	
Pusa grams .. ..	317 1 8	287.87	20 0	25.00	144 22 1	145.0	182	182.0	..	
Cotton C. A. 9 .. ..	43 23 8	358.70	..	..	..	..	..	..	..	
„ J. N. 1 .. ..	63 35 9	386.89	6 0	40.00	19 21 0	130.0	..	6 0	47.6	
Other improved cottons .. ..	11 37 0	90.40	..	..	..	..	..	..	..	
Jaunpur maize .. ..	1 23 8	1.27	..	..	12 80 0	50.0	..	0 5	1.0	
Juars.. ..	42 24 8	321.62	..	..	9 14 4	46.0	4	25.0	0 7	
Bajra .. ..	2 88 0	3.50	..	..	9 5 0	150.0	..	68	68.0	
Groundnuts .. ..	67 24 0	195.20	..	..	..	..	..	..	..	
Early arhar .. ..	16 27 11	57.08	..	..	18 24 2	100.0	..	..	0 8	
Improved cane .. ..	845 80 0	21.54	80 0	0.10	1,740 0 0	34.0	804	15.7	..	
Rice .. ..	..	..	..	..	..	..	..	..	..	
Jute .. ..	..	..	..	..	..	..	..	..	..	
Potato .. ..	8 20 0	0.70	5 0	1.00	..	..	..	..	..	
Sanai .. ..	1 0 0	1.00	..	..	0 89 8	1.0	..	..	..	
Peas .. ..	0 85 8	0.50	..	..	..	..	..	..	..	
Guar .. ..	2 25 0	8.40	..	..	..	..	..	..	..	
Oats .. ..	18 6 8	14.43	..	..	..	..	..	..	..	
Lucerne .. ..	3 6 12	22.78	..	..	..	..	..	..	..	
Barley .. ..	..	..	..	..	..	..	..	..	..	
Desi gram .. ..	..	..	..	..	..	..	..	..	..	
Barley and peas .. ..	..	..	..	..	..	..	..	..	..	

Statement showing distribution of Improved Seeds during 1923-24—(continued).

Name of seed.	Mainpuri farm.		Jasrana Central Co-operative Bank, Mainpuri.		Unao.		Hardol farm.		Agricultural Supply Society, Hardol.	
	Quantity.	Area.	Quantity.	Area.	Quantity.	Area.	Quantity.	Area.	Quantity.	Area.
Wheat Pusa 12 .. .. .	Mds. srs. ch. 138 0 0	110·0	Ms. srs. ch. 154 22 5	..	Mds. srs. ch. 893 27 12	558·0	Mds. srs. ch. 464 0 0	371·20	Mds. srs. ch. 1,066 5 14	852·8
Ditto 4 .. .. .	..	..	..	..	..	..	..	..	..	..
Other improved wheats .. .. .	..	..	125 39 1	..	..	..	..	..	..	..
Pusa grams .. .. .	5 5 12	5·0	9 14 6	..	..	..	59 16 0	59·4	..	..
Cotton C. A. 9 .. .. .	..	..	..	..	..	..	..	..	..	..
" J. N. 1 .. .. .	4 12 8	23·0	..	..	5 8 0	66·0	8 35 0	69·0	..	..
Other improved cottons .. .. .	0 21 4	3·5	..	..	0 1 0	0·81	..	..	..	..
Jaunpur maize .. .. .	0 84 0	6·0	..	..	..	..	2 17 8	16·25	..	..
Juar .. .. .	11 20 0	75·0	..	..	1 2 8	15·0	16 1 4	106·45	..	..
Bajra .. .. .	10 20 0	140·0	..	..	..	..	17 23 0	149·42	..	..
Groundnuts .. .. .	14 0 0	14·0	..	..	..	..	..	..	..	..
Early arhar .. .. .	1 5 0	7·0	..	..	0 5 0	3·00	..	..	..	..
Improved cane .. .. .	123 0 0	12·0	..	..	..	..	2,239 23 8	93·80	..	..
Rice .. .. .	..	..	..	..	..	..	..	..	..	..
Jute .. .. .	..	..	..	..	..	..	..	..	..	..
Potato .. .. .	..	..	..	..	..	..	..	..	..	..
Sannal .. .. .	..	..	..	..	..	..	..	..	..	..
Peas .. .. .	1 10 0	1·0	..	..	..	..	..	..	..	..
Guar .. .. .	0 12 8	1·0	..	..	..	..	..	..	..	..
Oats .. .. .	5 39 0	4·5	..	..	..	..	..	..	..	..
Lucerne .. .. .	0 11 0	2·0	..	..	..	..	0 2 0	0·50	..	..
Barley .. .. .	0 26 8	0·5	86 36 12	..	..	..	..	..	..	..
Desi gram .. .. .	..	..	159 31 6	..	..	..	..	..	..	..
Barley and Peas .. .. .	..	..	80 3 8	..	..	..	..	..	..	..

Statement showing distribution of Improved Seeds during 1923-24—(concluded).

Name of seed.	Sitapur.		Sitapur Court of Wards.		Jalaun.		Hamirpur.		Banda.		Total.	
	Quantity.	Area.	Quantity.	Area.	Quantity.	Area.	Quantity.	Area.	Quantity.	Area.	Quantity.	Area.
Wheat Pusa 12 ..	Mds. srs. 272 20	220·0	Mds. 560	500·0	Mds. srs. chs. 460 0 0	352·25	Mds. srs. chs. 1,111 88 8	1,112·0	Mds. srs. chs. ..	..	Mds. srs. chs. 8,999 94 2	7,065·86
Ditto 4 ..	..	..	..	..	.. 370 18 0	286·25	.. ..	..	.. 1,753 6 0	1,750·0	.. 2,999 82 0	2,118·41
Other improved wheats ..	..	..	..	..	.. 63 33 0	59·50	.. ..	..	.. ..	..	.. 109 19 4	98·60
Pusa grams ..	..	..	600	500·0	213 89 0	213·5	202 10 0	202·0	.. ..	..	1,744 14 5	1,619·77
Cotton C. A. 2 ..	..	..	..	..	.. ..	..	.. ..	..	.. ..	..	.. 43 23 8	858·70
" J. N. 1 ..	2 0	16·0	..	..	8 16 9	43·0	19 28 8	92·28	0 15 0	0·50	149 12 2	919·27
Other improved cottons ..	..	..	..	..	.. ..	..	.. ..	..	.. ..	..	.. 12 19 4	94·21
Jaunpur maize ..	..	..	..	..	.. ..	..	.. ..	..	8 16 2	23·00	21 6 2	97·52
Juar ..	..	..	..	..	.. ..	..	.. ..	..	8 4 0	65·00	92 23 8	655·27
Bajra ..	..	..	..	..	.. ..	..	.. ..	..	22 16 8	80·00	62 12 8	472·92
Groundnuts ..	10 0	10·0	..	..	.. ..	..	.. ..	..	6 39 6	56·00	166 28 6	233·60
Early arhar ..	..	..	..	..	.. ..	..	.. ..	..	.. ..	..	36 24 13	168·08
Improved cane ..	1,110 0	23·0	..	..	.. ..	..	371 0 0	10·12	125 0 0	4·97	8,458 13 8	159·73
Rice ..	..	..	..	..	.. ..	..	.. ..	..	24 14 0	43·00	28 14 0	43·10
Jute ..	79 25	1,297	..	..	.. ..	..	.. ..	..	.. ..	..	79 25 0	1,297·00
Potato ..	..	..	..	..	.. ..	..	5 22 0	1·25	26 12 4	5·50	40 15 4	8·45
Sansal ..	20 0	20·0	..	..	.. ..	..	.. ..	..	0 11 0	0·50	22 0 8	22·50
Pans ..	..	..	..	..	.. ..	..	.. ..	..	.. ..	..	2 5 8	2·50
Guar ..	..	..	..	..	.. ..	..	.. ..	..	.. ..	..	2 37 8	9·40
Oats ..	..	..	..	..	.. ..	..	.. ..	..	.. ..	..	23 33 8	18·93
Lucerne ..	..	..	..	..	.. ..	..	.. ..	..	.. ..	..	3 19 12	25·28
Barley ..	..	..	..	..	.. ..	..	.. ..	..	.. ..	..	87 23 4	0·50
Desi gram ..	..	..	..	..	.. ..	..	.. ..	..	.. ..	..	159 31 6	..
Barley and peas ..	..	..	..	..	.. ..	..	.. ..	..	.. ..	..	80 3 8	..

*Private Farms.*

It is very encouraging to note the number of private farms that have been established. These farms vary in size and equipment from the big farm of over 100 acres equipped with buildings and power machinery to the small plots of land of the lesser zamindars and cultivators managed on improved lines and using departmental seed. All form a nucleus for the spread of further agricultural activity in their vicinity.

*Errata to the Annual Report of the Agricultural Experimental Stations in Assam for the year ending the 30th June 1912.*

Page.	Para.	For.	Read.
1	2	0.048	0.018

Against Calcium Carbonate in column 2 of the Report on Analysis of Jorhat Farm Soil.

ANNUAL REPORT  
OF THE  
AGRICULTURAL EXPERI-  
MENTAL STATIONS

IN

ASSAM

FOR THE

YEAR ENDING THE 30TH JUNE 1912.



SHILLONG.

PRINTED AT THE ASSAM SECRETARIAT PRINTING OFFICE,  
1912.

## Annual Report on the Jorhat Agricultural Experimental Station for the year ending June 30th, 1912.

This station was established in the beginning of the year 1908 and is intended principally for the investigation of sugarcane. It is situated about 3 miles south of Jorhat town and has a total area of  $35\frac{1}{2}$  acres, of which 1.7 acres is *kola* or ravine land and the remainder high land which was under grass and scrub jungle at the time of acquisition.

2. The soil of the high land is a reddish sandy loam of the old alluvium lying on a hard greyish yellow sub-soil. Where the conditions have not been improved by cultivation, the soil is extremely shallow, varying from only 3 to 6 inches in depth.

The following report by Mr. A. A. Meggitt, Agricultural Chemist, Dacca, is given *in toto* :—

### Report on Analysis of Jorhat Farm Soil.

Chemical.	Surface soil.	Sub-soil.
	Laboratory No. 5.	Laboratory No. 5a.
1	2	3
<i>Soluble in hydrochloric acid with 12 hours' digestion at 100° C.</i>		
Phosphoric acid (P <sub>2</sub> O <sub>5</sub> ) ... ..	0.025%	0.026%
Po' ash (K <sub>2</sub> O) ... ..	0.115%	0.135%
Lime (CaO) ... ..	0.154%	0.144%
Magnesia (MgO) ... ..	0.166%	0.148%
<i>Solub'e in 1 per cent. citric acid with 7 days' digestion.</i>		
Phosphoric acid ... ..	0.008%	0.0008%
Potash ... ..	0.007%	0.011%
Loss on ignition (organic matter and combined water).	3.26%	1.84%
Nitrogen ... ..	0.114%	0.051%
Calcium carbonate ... ..	0.048%	0.018%
Reaction ... ..	Acid	Acid

*Physical constants.*

Hygroscopic capacity.	Maximum water-saturation capacity.		Minimum water-saturation capacity.		Moisture in air dry soil.	
	Per cent. of water in-saturated soil by weight.	Per cent. of water in-saturated soil by volume.	Per cent. of water by weight.	Per cent. of water by volume.		
1	2	3	4	5	6	
Surface soil	3.10	31.9	50.5	11.2	13.9	1.3
Sub-soil	...	30.0	50.0	7.2	9.1	1.19

**REPORT.**

"These analyses agree quite well generally with some others made some years ago by the Imperial Agricultural Chemist.

The samples are acid in reaction, and the total lime present in all combinations, as well as the carbonate of lime, is quite deficient in quantity.

Carbonate of lime has an enormous influence on a soil's welfare—chemically, physically, and bacteriologically.

Its effect on soil biological processes are in the right direction, and very great; it also influences the texture of soils in a remarkable way, and is active in bringing into use the reserves of dormant plant food. Its presence in fair amount also ensures the most economical effect of any manuring given. Its absence forbids the use, for most cropping, of certain kinds of manures, unless liming be first resorted to.

Any upland soil containing such small amounts of total lime and lime carbonate as are here present will most certainly respond markedly in the case of most cropping to applications of lime.



"The amount of organic matter is probably greater than obtains in many Indian soils, but there is no doubt that a light soil of this character will be much improved in many ways by an increase in the amount of humus. A good deal of the organic matter present is of a doubtful character, and consists very probably of very old residues of little value; it is the presence and active decay of comparatively recent additions of organic matter which puts life into a soil."

The percentage of nitrogen present in the surface soil is what would normally be considered a fair one, but in view of the absence in anything like adequate quantity of carbonate of lime conditions for nitrification are probably not as favourable as they might be by a long way, and an increase in the amount of nitrogen is indicated as desirable.

Of potash there is no dearth, and there would seem to be no immediate need for potash manuring.

Regarding phosphoric acid, these samples show a deficiency both in total as well as available supplies. There is thus a 'real' as opposed to a mere temporary lack in respect to this element of plant food.

This lack of phosphoric acid is further aggravated by the absence of sufficiently large amounts of lime carbonate and humus, high percentages of which may, and often do offset a smaller percentage of phosphoric acid.

An acid condition of soil, besides being harmful in itself, very often brings about a more rapid depletion of the soil's stock of phosphoric acid, in consequence of which most soils of a decidedly acid character are found to be lacking in this element, and to respond to its suitable application.

Turning to the physical constants, the hygroscopic capacity is low, and about what one would expect for this class of soil. It means that only water which is in excess of about 3 per cent. is available for crops, and plants are able to reduce the soil moisture content to somewhere about this figure before they begin to wilt. The top 6 inches of soil even during the cold weather normally contains a good deal more moisture than 3 per cent., when under a standing close crop, so that usually there is sufficient water for the crops requirements.

As regards maximum saturation capacity, these soils agree quite well with quoted figures for similar soils in Europe, and suggest that the optimum proportion of water for the growth of

"the plant is about 13—16 per cent. A recent determination of soil moisture in the surface 6 inches of the soil of this farm in August some few hours after rain gave 17 per cent. water. Soil moisture conditions are therefore probably extremely favourable for growth during the rainy season.

The figures for minimum saturation capacity are much lower than those cited (Hall, *The Soil*, page 69) for similar soils in Europe, and this is probably due to the lower content of humus which obtains in our soils. This is an extremely important figure in gauging a soil's power to retain a reserve of moisture for crops during dry periods.

The sub-soil is worse in this respect than the surface layer suggesting that the incorporation of organic matter, if it can be buried sufficiently deep, will have a very great ameliorating effect indeed.

The sub-soil is capable of very great improvement indeed, as the figures show, but it would probably be immediately disastrous to work it so deeply as to bring any considerable amount to the surface at once.

The growth of deep rooting legumes as green crops will assist materially, but if the sub-soil could be stirred occasionally while at the same time the surface cultivation is gradually deepened so that green crops may be more deeply buried, a greater depth of surface soil will result, which on this farm is very much to be desired.

I am convinced that for cane cultivation, until the surface soil has been deepened and the amount of humus increased, it is of little use attempting manurial experiments on cane with artificial manures. No amount or combination of the latter can ever make up in the case of a crop like sugarcane for loss of fertility due to shallow cultivation and lack of humus."

3. The farm is equipped with a godown, combined office and rest house, quarters for Farm Superintendent and two Apprentices and a cattle shed with brick walls and a corrugated-iron roof. Buildings and machinery, etc.

A three-roller cane mill 12 inches X 18 inches driven by a 9 B. H. P. Hornsby oil engine was installed in 1911.

It is proposed to build new quarters for the Fieldman Clerk during the coming year.

4. The rainfall recorded during the growth of the crops referred to is given in the following table together with the normal rainfall:—

Month.	Actual rainfall, in inches.	Normal rainfall, in inches.
1	2	3
1911, April ... ..	10·96	8·54
„ May ... ..	14·11	9·26
„ June ... ..	14·67	11·36
„ July ... ..	17·84	14·76
„ August ... ..	20·00	15·15
„ September... ..	16·46	9·18
„ October ... ..	8·90	4·07
„ November... ..	2·60	0·69
„ December ... ..	0·53	0·52
1912, January ... ..	0·67	0·93
„ February ... ..	2·24	1·82
„ March ... ..	3·71	3·90
Total ... ..	112·69	79·63
1912, April ... ..	10·67	8·54

The year was abnormally wet and dull, the rainfall being about 30 inches above normal. Between April 1st, 1911, and January 31st, 1912, rain fell on 88 days, while the number of sunny days was 141. Between the same dates in the previous year rain fell on only 53 days and the number of sunny days was 153. These abnormal weather conditions account for the late ripening of the ratoon crop, and also did much to encourage the outbreak of potato disease mentioned in paragraph 12.

Experimental work. 5. This consisted of—

- I. Experiments with sugarcane.
- II. Soil treatment investigations based on several years' field observations and on the result of the Agricultural Chemist's examination of the soil.
- III. Trials of various crops new to the locality.

Ratoon sugarcane.

6. The following varieties planted in Block E in 1910 were ratooned :—

1. Striped Mauritius	}	¼ acre plots.
2. <i>Tana</i> , ½ plot striped		
"   "   ½ plot yellow		
3. <i>Magh</i>		
4. <i>Kheri</i> .	}	¼ acre plots.
5. B. 147.		
6. B. 1753.		
7. B. 376.		
8. B. 208.		
9. <i>Teli</i> .		
10. <i>Vandamukhi</i>		

The results of the first crop are given in last year's annual report of this station. After the removal of the first crop in April 1911 all refuse was removed from the plots and the land was hoed. Two earthings were given, one during the last week of June and another at the end of July. As in previous years, all plots were given a dressing of 20 maunds of rape cake per acre, half at the time of the first earthing and half at the second earthing. Weeding was done once in July. Beyond the removal of dead leaves and diseased canes no other cultivation was given. As most of the varieties appeared to be ripe, harvesting was commenced in December 1911, but after a few analyses of juice, it was obvious that the canes were immature, so the remaining varieties were allowed to stand until the end of February, when experimental analysis show that the cane was as ripe as it was likely to get. In the following tables, therefore, the results of *Teli* and *Vandamukhi* which were harvested in December are not comparable with those of the other varieties which were harvested two months later. As in the previous year, the ratoon crop of *Magh* made such poor growth and was so badly diseased that it was not worth crushing.

The results of the remaining varieties are set out in table I and II. Table I gives the analysis of the juice and Table II the weights of cane, juice and sugar per acre, etc.

TABLE I.  
RATOON CANE, 1911-12.  
*Juice.*

	Area weighed and analysed.	Cane sugar, per cent.	Invert sugar, per cent.	Total sugar, per cent.	Glucose ratio.	Total solids, per cent.	Purity coefficient.	Remarks.
1	2	3	4	5	6	7	8	9
1. B. 376 ... ..	½ acre ...	16.74	0.44	17.18	2.63	17.8	94.0	
2. B. 147 .. ...	½ .. ...	18.15	0.20	18.44	1.60	19.4	93.5	
3. Striped Mauritius ...	½ .. ...	18.17	0.63	18.80	3.89	17.5	89.4	
4. B. 208 ... ..	½ .. ...	18.38	0.77	17.10	4.71	18.1	80.2	
5. Yellow Tana ... ..	½ .. ...	15.38	0.72	16.10	4.68	17.9	85.9	
6. Striped Tana ... ..	½ .. ...	14.63	1.14	15.76	7.80	17.1	85.5	
7. B. 1753 ... ..	½ .. ...	12.58	1.23	13.81	9.76	15.3	82.7	
8. Kheri ... ..	½ .. ...	11.30	1.67	12.97	14.78	14.9	75.3	
9. Vandamuki ... ..	½ .. ...	9.65	2.17	11.82	22.5	13.4	72.0	Cane looked ripe, but evidently was not.
10. Tali ... ..	½ .. ...	8.21	3.44	11.65	41.9	12.4	66.2	Ditto ditto.

The ratoon crop was later in ripening this year, due probably to the abnormally wet and dull season. This year's figures confirm the results obtained in previous years with regard to the high quality of the juice of B. 376, B. 147 and Striped Mauritius. This is the first time that B. 208 has matured a ratoon crop fit to harvest, as in other years it has been destroyed by disease; this year however although diseased to some extent, yet it comes out fourth best with regard to purity of juice. Of the other varieties, Yellow *T'ana* appears to be improving and B. 1753 deteriorating in respect of quality of juice.

TABLE II.

BATOON CANE, 1911-12. (Figures are "per acre".)

	Area weighed.	Yield of cane, per acre.	Yield of juice, per acre.	Percentage of juice on cane.	Total sugar per cent. on juice.	Total sugar per acre in juice.	Total cane sugar (sucrose).	Remarks.
1	2	3	4	5	6	7	8	9
		lbs.	lbs.			lbs.	lbs.	
1. B. 376 ... ..	½ acre ...	76,150	56,090	66.6	17.18	9,605	8,385	
2. B. 167 ... ..	½ " ...	56,740	39,760	59.5	18.44	6,235	6,127	Extraction Mill faulty.
3. Striped Mauritius ... ..	½ " ...	55,423	35,378	64.2	16.8	5,977	5,752	
4. B. 206 ... ..	½ " ...	55,350	34,600	62.5	17.10	5,017	5,680	
5. B. 1768 ... ..	½ " ...	54,940	35,000	63.7	13.81	4,354	4,403	
6. Kheri ... ..	½ " ...	37,120	33,510	68.7	12.97	4,346	3,786	
7. Striped Tona ... ..	½ " ...	36,900	23,033	59.2	15.76	3,650	3,367	
8. Yellow Tona ... ..	½ " ...	34,713	20,073	57.8	16.10	3,232	3,087	
9. Teli ... ..	½ " ...	56,980	24,233	60.1	11.65	3,983	2,810	Cane unripe.
10. Vandamukhi ... ..	½ " ...	41,410	26,000	60.4	11.82	2,955	2,413	Disto.

The chief feature of the above figures is the high yields of sucrose and total sugar per acre obtained from B. 376. This is the best crop we have ever obtained either from plant or ratoon cane since the experiments were commenced. Striped Mauritius is very much down in sugar per acre on last year's figures, due to an increased amount of disease in the plot. B. 208 has given nearly as good results as Striped Mauritius. The two *Tana* varieties have given little more than half the amount of sugar per acre as last year.

The percentage of juice on cane is in every case lower than that of last year. This is due to the fact that this year all the varieties were crushed with the power mill, while last year they were crushed with the three-roller iron bullock mills.

The low extraction in the case of B. 147 was caused by the mill having been opened out without instructions by one of the farm staff. Unfortunately this was not discovered until too late. It is only fair to state that under Factory conditions and expert control the percentage of juice extracted would be much greater and would amount to at least 75 per cent. of the weight of the cane in an efficient modern mill of 9 or more rollers.

7. The following varieties were grown on Block B (*vide plan*):—

Plant cane.

Striped Mauritius	} ¼ acre plots.
B. 147	
B. 376	
B. 1753	
B. 208	} 1/10 acre plots.
Striped <i>Tana</i>	
Yellow <i>Tana</i>	
<i>Magh</i>	
<i>Kheri</i>	

Both *Teli* and *Vandamukhi* were omitted on account of consistant poor results hitherto obtained.

The land was given a dressing of 50 maunds of slaked lime per acre in the spring of 1910 and was green manured with cow-peas in the following rains. It remained fallow during the cold weather of 1910-1911.

Well rotted cowdung was ploughed in previous to planting at the rate of 500 maunds per acre. The sets, which had all been previously sprouted in a nursery, were planted out in the field during the first week of May 1911. Subsequent cultivation consisted of hoeing, weeding and earthing. A hoeing was given



in the middle and another at the end of June. The crop was earthed twice, once in the first week of July and again in the middle of August. Stripping was done twice, once in October and again in December. Lodged canes were tied up and diseased canes removed and destroyed periodically throughout the season.

The crop was harvested and crushed between the middle of March and beginning of April 1912. The results are set out in Tables III and IV. Table III gives the analysis of the juice and Table IV the yields of cane, juice and sugar per acre, etc.

**TABLE III.**  
**PLANT CANE, 1911-12.**

*Juice.*

Variety,	Area weighed and analysed.	Cane sugar, per cent.	Invert sugar, per cent.	Total sugar, per cent.	Glucose ratio.	Total solids, per cent.	Purity coefficient,	Remarks.
1	2	3	4	5	6	7	8	9
Striped Mauritius ...	1/2 acre	17.80	0.33	18.13	1.90	18.59	94.5	
2. B. 376 ...	1/2 "	17.41	0.23	17.64	1.33	18.41	94.5	
3. B. 208 ...	1/2 "	18.10	0.32	18.42	1.77	19.3	95.8	
4. B. 147 ...	1/2 "	18.05	0.32	18.37	1.77	19.4	95.0	
5. Yellow Tona ...	1/2 "	15.01	0.73	15.74	4.58	17.4	86.3	
6. Striped Tona ...	1/2 "	13.95	1.10	15.14	2.33	16.8	83.0	
7. B. 1753 ...	1/2 "	11.87	1.37	13.24	11.54	14.55	81.6	
8. Khoré ...	1/2 "	13.15	.41	14.56	10.72	16.17	81.3	
9. Magh ...	1/2 "	11.25	1.43	12.73	13.13	14.2	79.2	

Here again the high quality of the juice of Striped Mauritius, B. 376, B. 208 and B. 147 is demonstrated, while the local variety *Magh* gives the worst juice of all the varieties experimented with.

**TABLE IV.**  
**PLANT CANE, 1911-12.**

Variety.	Area weighed.	Yield of cane, per acre.	Yield of juice, per acre.	Per cent. of juice on cane.	Total sugar per cent. on juice.	Total sugar per acre in juice.	Total cane sugar (sucrose) per acre in juice.	Remarks.
1	2	3	4	5	6	7	8	9
		lbs.	lbs.			lbs.	lbs.	
1. B. 147 ... ..	½ acre ...	85,500	36,528	65.7	18.37	6,710	6,504	
2. B. 376 ... ..	½ " ...	88,520	27,930	64.8	17.64	6,091	6,603	Half of this plot was topped for sets or yield would have been more.
3. B. 208 ... ..	" ...	84,120	35,310	65.2	18.42	6,564	6,391	
4. Striped Mauritius ... ..	½ A ...	55,864	35,500	64.9	18.12	6,443	6,330	
5. Yellow <sup>to</sup> Tana ... ..	½ B ...	67,080	40,440	60.3	15.74	6,365	6,070	
6. Striped Tana ... ..	" ...	66,740	40,000	59.9	15.14	6,056	5,580	
7. Kleri ... ..	" ...	57,400	32,320	61.3	14.66	5,128	4,632	
8. B. 1753 ... ..	½ " ...	55,170	34,170	61.9	13.34	4,524	4,056	
9. Moga ... ..	½ " ...	46,740	30,200	64.6	12.73	3,845	3,397	

In yield of total sugar and sucrose per acre B. 147 stands first, followed closely by B. 373. Striped Mauritius, although yielding well, gives a considerably poorer result than that obtained last year. This is probably due to the fact that it was more diseased this year than last. B. 208 has done extraordinarily well this year as compared with previous years, being third on the list as a sugar producer, whereas last year it stood ninth out of a total of eleven varieties tested. B. 1753 gives poor results as compared with the other Barbadoes varieties, as also does *Magh*.

8. This was laid down in Block B on four  $\frac{1}{10}$  acre plots. The ordinary method of planting used on the farm at present is in rows 3 feet apart with sets at intervals of about 2 feet in the row. This method was compared with planting sets end to end in rows 3 feet apart, end to end in rows 4 feet apart, and alternately in trenches 1 foot wide and 4 feet apart. Except as regards method of planting, these plots were treated similarly to those in the variety experiment. The sets were transplanted in the beginning of May 1911 and the crop was harvested during the first week of April 1912. The results are set out in the following statement :—

TABLE V.

PLANTING EXPERIMENT, 1911-12:

*Striped Mauritius,  $\frac{1}{10}$  acre plots.*

	Cane, per acre.	Juice, per acre.	Percent of juice on cane.	Cane sugar in juice, per cent.	Invert sugar in juice, per cent.	Total sugar in juice, per cent.	Glucose ratio.	Total solids per cent, on juice.	Purity coefficient.	Total sugar, per acre.	Remarks.
1	2	3	4	5	6	7	8	9	10	11	12
	lbs.	lbt.								lbs.	
Plot No. 1.—( $\frac{1}{10}$ acre weighed and analysed), ordinary method of planting, sets per plot 736.	60,240	36,860	61.2	15.79	10.83	16.48	4.37	17.40	90.7	6,075	Only half of plot 1 could be analysed. Engine gave out and r in came on, crushing was going on till night.
Plot No. 2.—(Rows 3' apart, sets end to end) ( $\frac{1}{10}$ acre weighed), sets per plot 1,233.	60,940	37,240	61.1	16.16	0.61	16.77	3.77	17.57	91.9	6,245	
Plot No. 3.—(Rows 4' apart, sets end to end, $\frac{1}{10}$ acre weighed, sets per plot 813.	56,950	34,840	61.2	16.80	0.41	17.01	3.47	17.73	93.3	5,926	
Plot No. 4.—(Rows 4' apart, sets alternate in 1' trench), $\frac{1}{10}$ acre weighed, sets per plot 684.	53,520	32,510	60.7	17.29	0.36	17.65	3.08	18.35	94.3	4,778	

The above results cannot be taken as conclusive for two reasons: first on account of disease which attacked the plots unequally, some plots being very much more diseased than others, and, second, because this is the first occasion on which such an experiment has been made at Jorhat.

Plot No. 2 is very little better than No. 1 in spite of the fact that it had over 5,000 more sets per acre. Plots 3 and 4 with higher seed rates than plot 1 both yield less sugar per acre although the juices are of slightly better quality. The greatest variation in sucrose content is 1.5 per cent. between plot 1 and plot 4, but as differences of as much as 1 per cent. sucrose are fairly common in two parts of the same plot, too much reliance cannot be placed on this figure.

On the whole, the results appear to give a general indication that about 7 or 8 thousand sets per acre is the maximum that can be used, and that any increase on this seems to act adversely. A smaller number may eventually prove to give better results, and work has now been commenced to determine this point.

9. The most striking fact brought out in this year's results is the great improvement in three of the Barbadoes varieties, especially B. 209, the plant crop of which has given an increase of about 2,000 lbs. of total sugar per acre over last year's crop. This variety is apparently accommodating itself to local conditions. The reverse is the case with B. 1753, which has been rapidly deteriorating and becoming more diseased for the last two years. We have accordingly been compelled to drop this variety altogether, as it was found impossible to select good healthy clumps for propagation. B. 376 ratoon was the best crop we have ever had at Jorhat. This variety at present is the most promising we have. Striped Mauritius, although still good, has not given such good results this year as usual on account of disease. Yellow *Tana* has proved itself to be a much better cane than Striped *Tana* both as regards yield and quality of juice; and being thinner than the striped variety it is more suitable for the mill.

Both *Magh* and *Kheri* have given poor results this year. While the Barbadoes varieties have been gradually improving, these two varieties have been deteriorating although the same treatment has been given them. It is a rather curious fact that since the experimental cane has been grown on limed land, the superior varieties of cane have been improving, while the more inferior varieties have gone back.

It is proposed to publish shortly an account of all the work done on sugarcane up to date at Jorhat, so to go further into the matter in this report is unnecessary.

10. As explained in the appendix to this report, being a "note on the occurrence of acidity in high-land soil," our attention was

Soil investigation.

first called to the existence of a high degree of infertility in the Jorhat soil in respect to certain cropping in the cold weather of 1907-08 when the oats crop well manured with cowdung, and after germinating well, suddenly failed and died out. This we attributed to lack of soil moisture at the time. Again, in the following cold weather 1908-09, on our second attempt with oats and also mustard sown after a green crop ploughed in during the rains, the same thing happened, but careful examination disclosed the fact that there was no lack of soil moisture when the crops failed. The surface soil was in excellent physical condition, and the way the seedling plants suddenly turned yellow and died down strongly suggested the presence of some noxious substance in the soil, whose effect become operative so soon as the young plants ceased to derive nourishment from the mother seed, and began to fend for themselves through the medium of their young delicate roots.

It so happened, however, that a small part of the area on which these crops were sown had received a dressing of wood ashes thrown out from the sugar boiling furnaces near by; on the land so treated quite good crops matured. This was suggestive, as the wood ashes were alkaline and contained lime and alkaline carbonates. About this time two plots out of a series going under cane were dressed with 10 maunds lime per acre; the cane was followed in the rains of 1909 by a crop of jowar for fodder, and it was observed that though all the plots had been well and variously manured otherwise, only on the two plots receiving the small lime dressing did any jowar survive at all; even here it made only a 2 to 3 feet crop, but over the rest of the area it turned yellow at an early stage and completely went out. Up to this time, no chemical work of a precise character had been possible on these soils owing to want of laboratory accommodation, but it was now undertaken, and in addition to being acid in character the soil was found to be deficient in lime and particularly so in lime carbonate and phosphoric acid. On the assumption that it was extremely probable that the crop failures above described were due to the deficiency of basic ingredients particularly of carbonate of lime, with accompanying acidity, which the soil examination now disclosed, we decided to make a preliminary soil experiment during the succeeding cold weather. *i.e.*, 1909-10, using only lime, and sowing amongst others such crops as up to then had failed every time,



A piece of high land was accordingly divided down the ~~centre~~ by a 3 feet path, and limed down one side only, at the rate of 50 maunds slaked lime per acre. This was admittedly a heavy dressing, but being desirous of making the issue decisive, and not then having that more or less precise information which we have now, it was considered desirable to err on the side of excess.

The lime was thoroughly worked in the surface 3 or 4 inches of soil, and four crops, *viz.*, gram, linseed, mustard and oats, were sown in strips right across both treated and untreated parts, so that each crop was sown partly on the limed and partly on the unlimed areas. No other manuring of any sort was given. The result was astonishing. The four crops germinated fairly well on both the limed and untreated land, but shortly afterwards all the plants on the unlimed land died off.

The mustard on the limed side also died out some time later after struggling for a while, but the oats, linseed and gram grew fairly well and were duly harvested. The yields were poor, but the fact that three out of the four crops matured anything at all in the absence of any other manuring, on the limed side, while dying out on the other, demonstrates that lime is a very important factor to be considered when dealing with this class of land.

Since this time, and up to last year, these two areas have been regularly cropped, without any manuring, with *aus* paddy during the rains, and the same four crops as above in the cold weather, and always with the same result in the latter case as described above. In the case of *aus* paddy the outturn of grain and straw off the lime side has each year been of the order of 2 to 3 times that yielded by the non-limed area.

The fact that the *aus* paddy produces a crop at all on the untreated area proves that it is more tolerant of the particular conditions which affect so adversely the other crops mentioned, but the respective outturns show that even *aus* paddy benefits by liming on our soil.

Last year, in view of the deficiency of phosphates in the soil and the fact that even limed land failed to mature the mustard crop, a slight variation was introduced into this experiment, a dressing of bone-meal being applied to half the area originally limed and along its entire length.

This had a very perceptible effect on the succeeding cropping, the growth of both the rains and cold weather crops being visibly better on the side receiving both lime and bone-meal, than on the area which had lime alone, and again the cropping on the latter showing the usual crushing superiority over that on the non-limed area.

The effect of the bone-meal was most marked on the mustard crop, the result being over 3 maunds of seed per acre, whereas heretofore even the limed land had failed to mature its crop as previously noted. The benefit conferred by bone-meal on the *aus* paddy, *matikalai* and gram was less pronounced, while in the case of the oat crop it was least evident. Its chief effect on the oats was to ripen the crop off earlier, and this is a point which is of great importance in Assam, where conditions demand that it must be sown in good time and harvested fairly early.

The experiment outlined above, and which has been carried on since the middle of 1909, has all along been regarded as a qualitative one, a feeler as it were to a more careful strictly quantitative experiment which, as will be seen later on, was subsequently laid down, being based on indications thus obtained. These indications, the result largely of observations during the actual growth of the various crops, have been all through so very pronounced as to leave no room whatever for doubt as to the treatment this class of land requires for mixed cropping.

In judging the figures given in Table VI it is necessary again to impress the fact that, barring the additions of lime and bone-meal, the area under experiment has never received an ounce of any other manure whatever, be it cowdung, green-manure or any other kind, since the time the farm was taken over by us. At that time it was very poor grazing land, growing only very coarse grass and scrub jungle.

The figures given below (Table VI) will illustrate the statements generally made above.

TABLE VI.

Crop.	1909-10.		1910-11.		1911-12.		
	Limed side.	Limed side.	Limed side.	Non-limed side.	Limed side.		Non-limed side.
					Lime and bone-meal.	Lime only.	
1	2	3	4	5	6	7	8
	Mds. srs.		Mds. srs.	Mds. srs.	Mds. srs.	Mds. srs.	Mds. srs.
Oats ... { Grain ... } { Straw ... }	5 24 (per acre)	Nil	0 7½ (per plot)	Nil	0 8½ (grain per plot).	0 8½ (grain per plot).	Nil.
Gram ... { Grain ... } { Straw ... }	0 30 ( " )	Nil	0 0 ( " )	Nil	0 1½ ( " )	0 0½ ( " )	Nil.
Matihalo ...	Not sown		Not sown		0 6½ ( " )	0 5½ ( " )	0 0½ (grain per plot).
Linseed ... { Grain ... } { Straw ... }	8 0 (per acre)	Nil	0 2 (per plot)	Nil	Not sown.		
Mustard, Grain ...	Nil	Nil	Nil	Nil	0 4 (grain per plot).	0 1 (grain per plot).	Nil.
Aus paddy { Grain ... } { Straw ... }	Not sown		0 20 (per plot)	0 7 (per plot)	1 12½ ( " )	1 16 ( " )	0 18½ (grain per plot).

## NOTE ON TABLE VI.

Some of the plots on which the various crops were sown were very small owing to the exigencies of space. Thus the recorded yields per plot are also necessarily very small. The figures might have been calculated to yields per acre, when the differences between the outturn of any crop from the treated and untreated plots would have appeared bigger.

However, as it was in most instances a case of no crop at all on the unlimed areas against some crop on the treated side, the yields per plot serve well enough, and, further, the experiment was never intended to be a strictly quantitative one.

It should be remarked, to prevent possible misunderstanding, that though owing to the shape of the total area in question the plots on which the different kinds of crops were sown differed in size, still the sub-plots receiving differential treatment under any one given crop, oats for instance, were all the same size, so that within the limits of one and the same crop in any one year they are quite comparative.

Following the indications yielded by the above preliminary scheme, we commenced now systematically to lime certain large blocks of land which come under our cane rotation.

The rotation is as follows:—

1st year ... Plant Cane ...	... }	Manured with cowdung and oil-cake.
2nd year ... Ratoon Cane	... }	
3rd year	{ Rains— <i>Aus</i> paddy ... Cold weather— <i>Matikalai</i> }	Non-manured.
4th year ... Cowpeas for green manure preparatory to cane again.	}	Non-manured.

The general result has been very noticeable in the cropping on these limed areas ever since, and as certain other areas on the farm have not been limed and have generally been carrying similar crops (barring cane), it has been possible to observe closely the general effect of the lime, and over large areas.

In the case of cane an immediate improvement in yield of cane and sugar per acre followed its introduction on to limed land, two of the most promising exotic varieties returning more than double the outturn of cane and sugar that they gave in the previous year with exactly the same manurial treatment, excepting that the land had received no lime. Other varieties also gave very great increases. Whether this is to be ascribed entirely to the action of lime on the crop, or whether it was in part due to more suitable climatic and general conditions during the year, one cannot definitely say, but when one considers the very great benefits conferred on other crops by lime, and that in the case of the two exotic varieties mentioned above, following their introduction on to limed land, the yields of cane per acre went up from approximately 21,000 and 23,000, respectively, to about 50,000 lbs. in each case, one can hardly doubt that the lime exercised a tremendous influence to bring about this result.

Regarding the other cropping in the rotation, the beneficial influence of the lime has again shown up very strongly on all. There is absolutely no comparison between crops of *matikalai* during the cold weather on limed and unlimed land, the yield of grain being approximately three times greater in the former case. Cowpeas, as a green manure crop, make very much healthier and stronger growth and a far bigger weight of green matter in a given time, when grown on limed land, though this crop has the reputation in America of being a suitable one for acid soils, and does at Jorhat make quite fair crops in the absence of liming.

Its value to subsequent crops as a fertilizer must be much greater when the soil contains a sufficiency of carbonate of lime.

Having thus definitely proved the great value of lime to many crops on this soil, it remained to further consider other aspects of its use, i.e., the extent and manner of its application, either alone or in combination with other manuring, with a view of building up such a healthy soil foundation as will permit of a greater variety in cropping.

Early in 1911 a further experiment was accordingly laid down on Block C with a suitable rotation of crops to continue for several years.

Block C Experiment.

It must be insisted at once that this is not a scheme designed to investigate the manurial requirements of any particular crop or crops ; it is really a soil improvement experiment in which certain manuring is given, based on the knowledge we now have of the soil's character and requirements in general, and in which several different crops are to be grown successively. These crops are to serve merely as indicators of the extent of the benefit conferred on the soil by differential manuring. Briefly then the experiment is an attempt to study the lime requirements of the old alluvial soils of Upper Assam, and the best method of its application, with and without green-manuring and again with and without the addition of phosphoric acid in the form of bone-meal, with special reference to cold weather crop production, which is at present almost an impossibility.

The addition of nitrogen in the form of cow manure is included and considered in combination with the above.

Bearing in mind then the scope and intentions of the scheme, and the varying requirements of different crops together with some inevitable local soil variations within the experimental area itself, it will be quite obvious that the indications of only one year covering only two crops cannot be very strongly insisted on. The results are, however, so striking in some of their aspects as to warrant mention, and to confirm us in the belief that information of very great and economic value as to the treatment of other soils under similar conditions of climate, etc., will be forthcoming with the lapse of time. It may further be pointed out that field experiments of this sort, extending over a long period and covering diverse cropping, furnish an opportunity for important Laboratory studies, and this aspect is not being lost sight of. Laboratory work is being taken up as time and opportunity permit, but in the absence of suitable accommodation for such work at Jorhat much valuable research that could otherwise be taken up must necessarily remain in abeyance, which is very much to be regretted, since the work cannot attain to its full value in such circumstances. The most suitable treatment for soils such as we are working on, and under the climate and cropping conditions obtaining, is, we are convinced, in many respects a very different problem from that which has to be faced in many other parts of India, and will bear and pay for much patient investigation.

It is part of our duty as scientific agriculturists to search out the fundamental principles underlying the successful treatment of these soils, and the process must be slow and expensive if the conclusions are to be sound,

The experiment on Block C is extended over two large blocks of land, the general manurial scheme being identical on both blocks, while the only difference that is made in the cropping is that one block will carry a crop of cowpeas for green manure every alternate rains, the other block being at that time under *aus* paddy.

Each block is divided into 4 equal parts, receiving respectively 0, 10, 30 and 60 maunds slaked lime per acre during the year under review. Further liming of the plots receiving the smaller dressings was contemplated, but will be subject to field observations combined with chemical studies as the experiment progresses.

Various cross-dressings of bone-meal alone, bone-meal and cowdung together, and cowdung alone were super-added. The bone-meal was applied before sowing the *aus* paddy, while the cowdung was applied during the preparation of the land for the oats crop in the cold weather.

The cropping during 1911 was as follows:—

Rains	...	{ One block under <i>aus</i> paddy. „ „ „ cowpeas for green manure.
Kharif	...	

## FIELD OBSERVATIONS DURING GROWTH—RAINS CROPS.

### *Aus* PADDY.

The direct results obtained from this crop were quite valueless for the following reason: This area was very full of weed seeds, and very soon after sowing the *aus*, a prolific growth of weeds appeared, particularly marked on the whole of the plots receiving lime, and even more pronounced in those parts cross dressed with bone-meal.

The weeds on the plots receiving neither lime nor bone-meal were scarcely in early evidence at all. While this immediate luxuriant growth of weeds was most satisfactory very early evidence as to the value of lime and more particularly of lime plus bone-meal on this land, evidence which would have been reproduced in the *aus* crop, had the weeds been removed, as things turned out, it went dead against the paddy.

The Farm Superintendent gives it as a fact that it was wholly impossible to weed the crop on account of persistent wet weather during the two months following sowing, the result being that the *aus* paddy was given a most serious check in its early days, while the weeds on the lime and bone-meal areas got such a strong lead as almost to choke out the crop.

Had the paddy once got away and made some growth, the result might have been very different, but the weeds took a strong lead from the very commencement, and weeding, being impossible it never got a chance. As things turned out, the result of this part of the experiment would have been more suitably decided by harvesting and weighing the weeds, rather than the little paddy which survived.

This is an excellent instance of how competition in nature can upset one's best laid plans. Competition of this sort in experimental work should never be allowed of course to interfere with the issues at stake, but it appears to have been unavoidable in this case according to the Farm Superintendent.

We hope that the lesson thus forcibly taught will not be lost upon the farm staff, and that is that when it is being attempted to grow a crop rather than weeds, the latter must be removed at the earliest possible moment after they have appeared. The outturns from the variously manured plots fully bore out the above field observation during the actual growing period, the plots receiving no manure returning the biggest yield of paddy, the yields diminishing with increasing doses of lime up to 30 maunds per acre and being least on those parts receiving both lime and bone-meal.

We are convinced that the above is the true explanation of the comparative failure of the *aus* crop, a conviction which is strengthened by the observations we have made on other parts of the farm as to the well-marked beneficial effect of lime and bone-meal on the same crop under ordinary conditions.

#### COWPEAS FOR GREEN MANURE.

This crop sown early in June showed up the effects of manuring very well, and though in this case the weeds also made more growth on the manured parts, the cowpeas there made better growth also, and smothered them finally. The heavier dressings of lime produced the strongest and heaviest crops, and the effect of the bone-meal was also well marked. It was dug in during August, and decayed rapidly, providing an excellent seed bed for the succeeding oats crop.



## RAPI CROP.

"Oats": It is, we believe, on the cold weather cropping that the scheme of manuring will show up to the greatest advantage. As already mentioned, this soil without treatment refuses to produce cold weather crops at all in most cases, and only very feeble ones in others, *e.g.*, *matikalai*.

Our expectations were fully realised, the outturn of oats grain varying from absolutely nothing on the plots receiving no lime, up to over 23 maunds per acre from the heavier dressed lime plots on the green manured block, the weight per bushel varying from 33 lbs. to 41 lbs., the latter being quite a good figure for oats even in Europe.

## FIELD OBSERVATIONS DURING THE GROWTH OF THE OATS CROP.

Comparing the crops as a whole on the block previously green-manured with that on the non-green-manured block, the benefits conferred on the oats by the green manure were very obvious right from germination to ripening in the healthier colour and stronger growth of the crop.

In regard to other manuring the action of lime was very pronounced again, the young seedlings early dying out on the non-limed areas on both blocks; the positive action of the lime was greater with increasing applications up to 30 maunds per acre, whether used alone or in combination with other manures. The area receiving 60 maunds per acre of lime never looked any better than the 30-maund plot, and towards ripening it appeared inferior; germination was also inferior on the 60 maunds lime plots.

The effect of the bone-meal was more apparent on the green-manured area right through the growing period than on the other block, while in both cases its action was most clearly marked in the early stages of growth. This early superiority, however, was not so marked later on.

The use of cowdung on all the limed plots showed a very early and marked beneficial effect which persisted throughout.

The application of bones and cowdung to the non-limed areas resulted in the young plants struggling on for a time, but the final result was only a few straggling and stunted stalks.

As regards the effect of the manures on ripening it was clear that both bone-meal alone or cowdung alone advanced the ripening somewhat. Those plots which received both

bone-meal and cowdung ripened their crops off earlier all over, but the very earliest ripening occurred where these two manures were combined with the heavier lime dressings.

There was a difference of at least a fortnight or three weeks between the earliest and latest plots to ripen off their grain.

The above observations were generally confirmed by the results which will be readily gathered from the subjoined table.

# BLOCK C.

## OATS, 1911-12.

Cross dressings.	Non-green-manured block.				Green-manured block.			
	No lime.	Lime 10 maunds per acre.	Lime 20 maunds per acre.	Lime 40 maunds per acre.	No lime.	Lime 10 maunds per acre.	Lime 20 maunds per acre.	Lime 40 maunds per acre.
	1	2	3	4	5	6	7	8
	Mds. str.	Mds. str.	Mds. str.	Mds. str.	Mds. str.	Mds. str.	Mds. str.	Mds. str.
<i>Nil.</i> ... ..	<i>Nil.</i>	7 5	12 5 (89)	10 20 (36)	<i>Nil.</i>	20	13 27½ (35)	12 25 (33½)
Bone-meal 3 maunds per acre ...	<i>Nil.</i>	6 30	11 20 (37)	10 30 (29)	<i>Nil.</i>	(36½) 20	16 30 (35)	12 25 (33½)
Bone-meal 3 maunds, cowdung 100 maunds per acre.	2 0	8 37½ (38½)	18 15 (41)	12 25 (36)	.	16 10 (38)	19 0 (34)	22 10 (37)
Cowdung 100 maunds per acre...	1 5	11 0 (37½)	15 32½ (140)	12 32½ (33)	3 0	16 27½ (39)	22 5 (35)	23 10 (33)

\* There was a very small crop here, but it was not weighed, by mistake.

Figures in brackets=weight in lbs. per bushel of grain.

Figures not in brackets=yield per acre of grain in maunds and seers.

While we have no desire to lay too much stress on the figures in the above table for reasons previously explained, the experiment being very young and the surface soil varying in depth at present over different parts of the area, still there would appear to be certain issues quite clear and outstanding, which can hardly by any stretch of the imagination be attributed to experimental error. These are as follows :—

- (1) The general marked superiority in yield of the green-manured block over the other.
- (2) The increasing positive effect of lime up to an application of 30 maunds per acre.
- (3) The very strong influence, on the crop, of cowdung when used with lime, and especially prominent on the green-manured area.
- (4) The impossibility of getting any crop of oats by any manuring so far tried, in the absence of lime.

The figures of yield returned by the plots receiving bone-meal are curious. In the non-green-manured block the use of bone-meal alone with the varying lime dressings resulted in two cases out of three in a slightly lower yield, a diminution however which is well within the limits of experimental error.

On the contrary, on the green-manured block the use of bone-meal alone returned a higher yield, in one case notably higher, which would rather go to show that the decay of the green matter in the soil has some influence in rendering available the insoluble bone-meal added.

Again while the addition of cowdung along with bone-meal raises the yield of all plots considerably, still in all cases but one the use of cowdung without bone-meal gave generally a slightly bigger outturn. Beyond an expression of the opinion that for certain cropping, oats for instance, one would not expect a marked or quick response to phosphate applied as bone-meal on this light soil, which, though deficient in phosphoric acid, still allows for considerably more root range than is possible in stiffer and more clayey soils which often do give in wet and warm climates a very ready response to bone-meal, at present we do not presume to offer any explanation of this, and can only regret that the land at our command did not permit of further duplication.

The inclusion of a variety of cropping in subsequent seasons will no doubt throw more light on this matter, and put a very different complexion on things in regard to the use of bone-meal on this soil.

## FINANCIAL ASPECT.

With respect to the financial aspect of the oats crop, reckoning the cost of the manures used during the year entirely to this crop, some very interesting results emerge. The oats were sold locally at Rs. 3 per maund.

The 10 maunds lime plots on the green-manured block all returned a profit; that plot receiving 100 maunds cowdung in addition showed a net profit of Rs. 23-8 per acre, being at the rate of 89 per cent. on an extra outlay of Rs. 26-9 per acre.

In two cases out of four the 10 maunds lime plots on the non-green-manured block also showed profits, *i.e.*, where used alone, and with cowdung.

With slaked lime costing us Re. 1-11-6 per maund, in those cases where large applications have been used, nothing but losses could well be expected to accrue, charging the whole cost to the single crop. Nevertheless perhaps the most astonishing result was that from the plot receiving 30 maunds lime and 100 maunds cowdung, after green manure, which yielded a crop of over 22 maunds grain per acre, and returned a net profit of Rs. 5-7, being at the rate of 9 per cent. on an extra outlay of Rs. 61 per acre.

Lime at Re. 1-11-6 per maund is almost prohibitive, but if recently discovered deposits result in its being placed on the market at reasonable rates, there would appear to be a tremendous field for its profitable use in Assam.

In considering the figures quoted above, it is necessary to impress the fact that the whole cost of the manuring has been charged against the one oat crop. In the case of the heavier dressings of lime, which will not be repeated during the course of the experiment, and whose effect will presumably persist for a number of years, this is obviously unfair; there can be no doubt however that the temporary losses now shown in their case will be converted by succeeding crops into profits, and probably very large ones.

## SUMMARY.

If one may be permitted to draw any conclusions so early, they would be as follows:—

- (1) For the oats crop, on this class of soil, the use of moderate applications of lime, not exceeding 30 maunds per acre, together with good dressings of organic matter either in the form of green manure or cowdung, or preferably both, would appear to be prime essentials.

- (2) In the absence of lime, even after green-manuring, neither cowdung alone, nor bone-meal alone, nor the two together will produce a crop of oats.
- (3) Even as small an application as 10 maunds lime per acre has a big effect on our soils, but is too little to produce a full crop of oats.
- (4) In soils deficient in organic matter as ours are, in the absence of green-manuring, even though cowdung be used, the application of more than 10 maunds of lime per acre in any one year would not appear to be sound.
- (5) Judging by its effect on oats, the use in one application of more than 30 maunds of lime, even along with the incorporation of very large amounts of organic manures, cannot be considered good policy on our soils we think, for the increased yield is not commensurate with the extra expense incurred, while the grain certainly does not fill so well.

Wood ashes experiment. Last year also, in view of the cost of lime and with the idea of finding a cheaper substitute which the cultivator might use, an experiment in the use of wood ashes in varying applications, with and without cowdung, was commenced.

Briefly it may be said that qualitatively the effect of wood ashes, as shown by its effect on oats, was the same as that of lime, but quantitatively the result weight for weight is nothing like so great as that of the latter.

Still it does effect an immediate soil improvement, and it seems likely that by the continuous application of wood ashes by the ryot in such quantities as he can accumulate year by year, a very substantial amount of improvement would be the result.

From the ryot's point of view, therefore, this experiment will with lapse of time possibly prove of the very highest value.

11. This crop has been grown annually for the last four years at Jorhat. During the year under report a little over an acre was planted on land which had been limed at the rate of 25 maunds of slaked lime per acre. In addition a dressing of 150 maunds of cowdung per acre was ploughed in previous to planting. The nuts were planted on May 25th and harvested in December, the yield being 30 maunds per acre.

Judging from the results obtained with this crop during the last four years, there appears to be no doubt but that it can be grown successfully in Upper Assam. The chief drawbacks to its introduction to local cultivators are its liability to the attacks of rats and also the difficulty of harvesting the crop.

12. Small areas of Darjeeling and Nainital potatoes were sown in the kitchen garden, with seed obtained from the hills. Unfortunately both varieties were attacked by disease (*Phytophthora infestans*), and although spraying with Bordeaux Mixture was resorted to, the plants died prematurely. The yield per acre of the Darjeeling variety was 80 maunds and that of Nainital 60 maunds.

Potatoes.  
This is the first occasion on which this disease of potatoes has been reported from the plains of Assam. The cause of its appearance this year was probably that rain fell every month throughout the cold weather, as it is a well-known fact that damp weather favours its propagation. The infection must have been carried in the seed tubers which were obtained from Darjeeling and Nainital, respectively. This experience comes as a timely warning that in any attempt to introduce potatoes to this locality great care must be taken to import only such seed as is above suspicion of carrying this disease.

13. *Aus* paddy was sown on Block D after ratoon sugarcane. Owing to continuous rain the crop could not be properly weeded and the outturn was poor.

Other crops.  
This was followed by a crop of *matikalai* in the cold weather also without manure. The crop grew very much better on the portion of the field which had previously received a dressing of lime than on the non-limed areas.

Oats were sown as the *rabi* crop in the manuring scheme on Block C. The results obtained with this crop are discussed in paragraph 10.

Cowpeas for green manure were sown on the whole of Block A in preparation for sugarcane.

14. Mozaffarpur lichis are now bearing well and the fruit is large and of excellent quality. Propagation by layering is in progress.

Fruit.  
Pineapples are also a success, specially the Ceylon variety. The West Indian and Spanish varieties have not done so well.

Of the other fruits, guavas and papayas are doing fairly well, but the citrus trees has all been killed by borers.

The mango trees are stunted in growth and have not up to the present borne any fruit.

15. The receipts amounted to Rs. 2,194 (chiefly by sale of *gur* and groundnuts), of which Rs. 48 was outstanding at the close of the year. The total expenditure was Rs. 7,075, which included Rs. 1,801 for establishment and Rs. 628 for capital charges.

Receipts and Expenditure.

16. This consists of a Farm Superintendent on Rs. 100—10—200, a Fieldman clerk on Rs. 25—1-8—40 and a peon on Rs. 8.

Establishment.

Since November 1911, M. Fazlal Haq Ahmed, a graduate of the Poona Agricultural College, who is under training for a post of District Agricultural Officer, has been stationed on the farm and has been placed in charge of demonstration work in the Jorhat subdivision. To assist him in this work he has the services of two demonstrators trained as apprentices on the farm for two years.

17. The farm was inspected in February by the Inspector General of Agriculture and once during the year by the Director of Agriculture, Eastern Bengal and Assam, and the Director of Land Records and Agriculture, Assam. The Agricultural Chemist stayed at Jorhat a considerable time in the spring in connection with the analysis of sugarcane and other work. The Deputy Director visited Jorhat eight times during the year and stayed for several days on each occasion.

Inspection.

Among other visitors were Sir Bampfylde Fuller, the Deputy Commissioner and Assistant Commissioner, Jorhat, the Civil Surgeon, Jorhat, and Mr. Blackwood, I.C.S., Officer on special duty for cattle survey.

18. A piece of adjacent high land about 20 acres in area has recently been acquired. It is proposed to bring this under cultivation during the ensuing year in preparation for further work on sugarcane and soil investigations.

Extension of area.

A. G. BIRT,

*Deputy Director of Agriculture, Assam.*

A. A. MEGGITT,

*Agricultural Chemist, Bengal.*



## APPENDIX.

**Preliminary note on the occurrence of acidity in high land soils.**

Our attention was drawn to the occurrence of well-marked acidity in high land soil both at Dacca on the stiff red old alluvium, and at Jorhat where the soil is still old alluvium but more sandy, when considering the infertility of these soils, which is most marked during the cold weather.

The possibility of the existence of a high degree of acidity in such high land and often well-drained soils, is one which up to now has perhaps not received the attention it deserves in those tracts in India where conditions, climatic, etc., generally might be supposed to tend to soil acidification. The common idea that an injurious degree of acidity is confined to lowlying marshy or peaty soils is wholly erroneous, as our work on some high land and quite well drained soils proves.

We have reasons to believe that the occurrence of such a degree of acidity as is positively injurious to many cultivated crops is far more widespread in North-Eastern India than may be commonly supposed.

This might be explained on the grounds that these soils may have been originally formed from rocks more or less deficient in basic ingredients, and that the amounts of lime, etc., present in these soils originally have been subjected to gradual but certain diminution, by removals in drainage water in a region of heavy rainfall, and by the constant withdrawal in crops of basic ash ingredients which exist as neutral salts in the soil.

The preferential leaching of lime is well known; when this process has gone far enough to establish a certain degree of acidity, the conditions set up favour the increased removal in drainage water of other plant foods, notably phosphoric acid, so it comes about that acid soils are generally more or less deficient in phosphoric acid, and pay for its suitable application.

Most cultivated crops prefer a neutral or very faintly alkaline soil, but it so happens that some crops are more tolerant of acidity than others, that is to say, when grown in an acid soil, they make fair or even good growth, while others either succumb or make very poor stunted unhealthy growth.

The fact that some crops do well on acid soil is no proof that they therefore prefer it to a neutral or faintly alkaline one, or that they would not do better on the latter kind of soil; it is a question of competition in nature, and it is simply because they have a greater, and other plants a less, tolerance towards acidity that the latter succumb and the former are finally given an undisputed field, hence in many cases giving rise to erroneous conclusions.

It is possibly this fact which has tended to divert attention from the undoubted evils that soil acidity exercises in the case of many cultivated crops, and has probably caused the failure of certain crops, and not of others, on this class of land to be ascribed to other than the true cause, failure being attributed to lack or excess of moisture, bad germination, fungus attacks, etc., in ignorance of the real reason underlying it. This happened early on in our own experience at Jorhat when an entire failure of the oat crop, on land which produces fair crops of *aus* paddy and which before sowing the oats had a good dressing of cowdung, led us to suspect lack of soil moisture as the cause.

Examination proved that this was not the case. The seeds germinated perfectly and grew to a few inches in height, then suddenly turned yellow and died out. The top 6 inches of soil was in quite good physical condition and there was plenty of moisture within 2 inches of the surface, and conditions for aeration are in this soil first class.

A crop of *matikalai* sown at the same time not only germinated but made poor to fair crops. In view of all these considerations then we were driven to seek another cause and found it was located in the acid condition of the soil. Analysis showed a deficiency of basic ingredients to which the accumulation of compounds toxic to the plant may be attributed, and as a further result of which soil acidity accrues. It does not follow that the toxic compounds are themselves acid, yet it appears probable that in view of the remarkable action of lime on these soils that the toxins are either acids or acid compounds, and moreover they are probably only formed or at least able to accumulate to a dangerous degree in soils very deficient in carbonate of lime.

Recent work, not yet completed, has disclosed the presence in these soils of an organic compound acid in character, definitely toxic to certain seedling plants, but the noxious character of which in such cases is minimised or entirely negatived by addition of lime to neutrality. This laboratory work agrees entirely with

field observations and fixes the characteristic infertility of these soils, with respect to certain cropping, as due, in the main, to a definitely toxic organic compound, acid in character, the evil effects of which may be largely, if not entirely, overcome by the use of lime.

It is well known that lime brings about many changes of a chemical, physical and biological character in soils; most soils contain sufficient lime to supply the food requirements of crops for this substance, and we have figures which prove that one of its least actions on our soils is as a direct source of plant food. We are convinced also that little of its action is to be ascribed to physical changes, at any rate at Jorhat.

That it induces very much improved biological conditions is evident in the very much healthier tone and darker green colour of crops which follow its application. Probably its greatest function is the establishment of sound healthy soil conditions by its action on the noxious acid compounds present. It is highly improbable that nitrification is entirely suspended on these acid soils, yet it is possibly so far reduced that plants cannot obtain, in the form of nitrates, all the nitrogen which they require, hence those crops which depend for their nitrogen supplies chiefly on nitrates suffer more from an acid soil condition than others which have the power of drawing upon other combinations of nitrogen to a greater extent.

Our early experience with oats, previous to the sowing of which a heavy dressing of cowdung was given, but no lime, and still failed to produce any crop, proves that acid soils are entirely uneconomical of manuring; it is in agreement with universal experience that the most economical soils are those which are neutral or faintly alkaline.

It is highly probable, considering the nature of these soil toxins, that deep cultivation and thorough aeration combined with the growth and incorporation of green crops will tend to improve matters, but it will take much time compared with the rapid action of lime, and moreover on many soils the addition of some lime would seem to be almost a necessity to secure even a decent green crop for turning in.

Our experiments up to date tend to show that the neutralising effect of lime dressings is not exerted to any appreciable extent below the depth to which it is mixed with the soil during the ordinary process of cultivation. That this is true may be gathered also from Rothamsted experience; during the 18th century and earlier repeated "chalking" with chalk rock drawn from 10 to 12 feet below the surface was practised there. To-day it is

stated that lime carbonate is only found in the surface soil. Moreover judging from the cropping to date, our results indicate that for most common field and garden crops it is not even desirable that the acidity should be neutralised to any very great depth, and that if the soil be limed sufficiently to render the top 4 inches or so very faintly alkaline, so far as immediately succeeding crops are concerned, it is not only needless but possibly occasionally harmful to apply more lime than will neutralise the soil to cultivation depth. Though applied lime may subsequently not be found to any great extent except in the surface soil and to ordinary cultivation depth, still this does not preclude its action extending further down, because the passage of soluble bicarbonate of lime downwards during drainage can still bring about flocculation, precipitation and other changes in its path, and this constant leaching of bicarbonate is a well known phenomenon.

The deeper the cultivation, of course the more lime will be needed to neutralise the acidity, because the added lime will thereby be spread over a larger volume of soil.

While our results so far thus show that it is probably better practice and more economical of lime to boot, to apply only such quantities as will render the soil faintly alkaline to the ordinary cultivation depth, they also prove that to apply any less quantity than will ensure this is not enough to produce full crops, and that though lime be applied in smaller quantities at intervals, ultimately the soil must be rendered faintly alkaline to the depth of cultivation practised.

Lime should be intimately mixed with the soil as soon as possible after application; otherwise its full early effect will not follow.

For ordinary agricultural practice it should be endeavoured, we think, to keep it fairly near the surface.

The amount of lime which it is safe or advisable to use depends, of course, on a number of other considerations besides the degree of acidity, and the depth of cultivation commonly practised; such factors as the cropping to be followed, and the continued use of certain artificials, *e.g.*, sulphate of ammonia, have also to be considered.

Our work in connection with the lime problem is being extended to include other phases of its use than those briefly touched on above.

For the present it is enough to point out the fact that acidity does occur in high land soils, in some cases where one perhaps might not expect to meet it, and whatever may be the action of lime, to enforce the recognition of its great value as an ameliorating agent.

A. A. MEGGITT,

*Agricultural Chemist to the  
Government of Bengal, Dacca.*

A. G. BIRT,

*Deputy Director of Agriculture, Assam.*

*Dated Shillong,  
The 12th September 1912.*

## REPORT ON THE UPPER SHILLONG AGRICULTURAL STATION FOR THE YEAR 1911-1912.

The Upper Shillong Agricultural Station was established in 1897-98. It is situated on the Cherrapunjee road,  $5\frac{1}{2}$  miles from the town of Shillong, and occupies the site of the old "Model Farm," which ceased to exist in 1879. The elevation of the Station is 5,900 feet, *i. e.*, about 900 feet higher than Shillong town. A large area of pine forest was annexed to the Station in 1905. The total area of the Farm, inclusive of forest, is 336.67 acres. Most of the cultivated land lies on the slope of a long narrow valley, the bottom of which consists for the most part of marshy land covered with a thick growth of wild grass. A considerable area of land has been reclaimed by deepening and straightening the stream which drains the valley and cutting lateral nullahs to connect with it. This work is being continued and extended, but the results of the work already done are very apparent. Soft boggy ground on which previously it was unsafe to work has been converted into firm pasture land and at the same time the herbage shows a marked change for the better.

The soil of the greater part of the Station is a coarse reddish loam of very loose texture which can be worked with the greatest ease. The sub-soil is of a more pronounced reddish colour and of great depth. In a small portion of the Station the soil is black owing, it is believed, to the existence of some mineral compound. The soils have not been analysed. In point of quality, they are extremely poor, and very little can be grown on them without the help of manure. At the bottom of the valley a different type of soil is found, namely, clay or clayey loam, extremely rich in organic matter. Having been under a thick growth of grass for many years, the upper portion of this soil is a matted mass of half decayed grass roots.

Besides the natural poverty of the soil, the greater portion of the Station suffers from the disadvantages of an exposed situation. It is colder and more windy than Shillong: frosts are of very common occurrence and are more severe than in

the town. During the winter the growth of vegetation is entirely suspended.

2. The main objects for which the Station was established were the introduction of superior varieties of potatoes—which are the most important crop grown on the plateau of the Khasi Hills—the breeding of improved strains of cattle suitable for this tract, and the cultivation of fodder crops and making of ensilage for use in winter when green fodder is short. These objects are still kept in view and in addition sheep breeding experiments with the object of improving the local breed have since been commenced.

3. The following table gives the rainfall during the year under report:—

Weather.				
1911.	July ...	...	14.52	inches.
	August ...	...	9.75	„
	September	...	11.32	„
	October	...	8.47	„
	November	...	0.14	„
	December	...	0.06	„
1912.	January	...	0.15	„
	February	...	0.84	„
	March ...	...	3.93	„
	April ...	...	9.19	„
	May ..	...	8.42	„
	June ...	...	16.82	„
	Total ...	...	83.61	„

The rainfall, although very much less than that of the previous year, was very well distributed, and on the whole the season turned out to be a good one for the potato crop.

4. The work done during the year included:—

- Summary of work.
- Reclamation.
- Potato experiments.
- Trials of various fodder crops.
- Trials of other new crops including flax and soybeans.
- Growing fodder crops for silage and hay.

Cattle breeding.

Sheep breeding.

Demonstrations on cultivators' holdings.

5. About thirty acres of pine forest was cleared during the year and put under cultivation. Seven acres of this new land was put under maize for silage and about  $8\frac{1}{2}$  acres under soybeans for green manure, the remainder being left fallow.

An attempt was made to bring a portion of the peaty soil in the valley under cultivation, but was not very successful owing to the boggy nature of the soil. About 9 acres of this was sown with raishan for hay, and about  $1\frac{1}{2}$  acres with hill paddy. The crops have not done well owing to the enormous growth of marsh weeds which could not be kept down, but some of the raishan will be fit for making hay.

Potato experiments. 6. These were similar to those carried out in 1911 and included :—

1. Variety tests.
2. Summer-grown *versus* winter-grown seed.
3. Whole *versus* Cut sets.
4. Methods of planting.

There was also another experiment to test the effect of a small dressing of lime on the crop, but I find that it was not carried out properly, hence the results are worthless.

A considerable area of two superior varieties of potatoes which have been proved by several years' experiment was planted to produce seed for distribution to hill cultivators.

Variety tests. 7. The following varieties were tested on duplicate plots,  $\frac{1}{40}$  acre in area :—

Khasi Round,	obtained locally,	in 1900.
Khasi Nainital,	ditto.	
King Edward VII,	from England,	1906.
Sutton's Magnum Bonum,	ditto,	1903.
King of Potatoes,	ditto,	1906.
Windsor Castle,	ditto,	1909.
British Queen,	ditto,	1909.



Up-to-date,	from England, 1909.
King of Potatoes,	ditto, 1912.
Magnum Bonum,	ditto, „
Windsor Castle,	ditto, „
British Queen,	ditto, „
Gladiator,	ditto, „
Flour Ball,	ditto, „
Harbinger,	ditto, „
Imperator,	ditto, „
Belle de Juliet,	ditto, „
White City,	ditto, „

All the varieties, except King of Potatoes, which was received from England about a month later, were planted in March and harvested in the first-half of August. All plots received a dressing of 300 maunds of cow dung and 10 maunds of rape cake per acre, and the potatoes were sprayed with Burdeaux mixture at the rate of 240 gallons per acre in two sprayings of 120 gallons each.

The following statement shows the average yield per acre of duplicate plots for the last five years:—

Variety.	1912.		1911.		1910.		1909.		1908.		Average of last two years.		Average of five years.	
	Mds.	Srs.	Mds.	Srs.	Mds.	Srs.	Mds.	Srs.	Mds.	Srs.	Mds.	Srs.	Mds.	Srs.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1. King of Potatoes (1906) ...	234	...	201	...	131	20	95	80	319	...	217	20	196	10
2. King of Potatoes (1912) ...	174	...	...	...	...	...	...	...	...	...	...	...	...	...
3. Magnum Bonum (1908) ...	232	...	160	85	132	20	87	80	277	...	196	17	178	1
4. Magnum Bonum (1912) ...	224	...	...	...	...	...	...	...	...	...	...	...	...	...
5. Windsor Castle (1909) ...	205	...	181	15	63	15	...	...	...	...	193	7	...	...
6. Windsor Castle (1912) ...	196	...	...	...	...	...	...	...	...	...	...	...	...	...
7. British Queen (1909) ...	181	20	189	85	92	30	...	...	...	...	185	27	...	...
8. British Queen (1912) ...	79	20	...	...	...	...	...	...	...	...	...	...	...	...
9. Up-to-date (1909) ...	178	...	153	...	90	...	...	...	...	...	165	20	...	...
10. King Edward (1906) ...	128	20	168	13	73	20	90	15	269	...	145	36	145	37
11. Khasi Nainital (1900) ...	166	20	157	80	119	...	111	30	292	...	162	5	169	16
12. Khasi Round (1900) ...	111	20	135	2	95	25	102	25	255	...	123	11	189	38
13. Gladiator (1912) ...	98	20	...	...	...	...	...	...	...	...	...	...	...	...
14. Flour Ball (1912) ...	173	...	...	...	...	...	...	...	...	...	...	...	...	...
15. Harbinger (1912) ...	126	...	...	...	...	...	...	...	...	...	...	...	...	...
16. Imperator (1912) ...	211	...	...	...	...	...	...	...	...	...	...	...	...	...
17. Belle de Julliet (1912) ...	81	20	...	...	...	...	...	...	...	...	...	...	...	...
18. White City (1912) ...	80	20	...	...	...	...	...	...	...	...	...	...	...	...

King of Potatoes (1906) has again given the heaviest yield, while Magnum Bonum (1908) is a good second. Judging from the results of the past five years, these two varieties can be relied on to produce a heavier yield than any of the other varieties; consequently we have made arrangements to produce large quantities of seed of these varieties for distribution to cultivators.

The newly imported seed from England has not given such good results as the farm-grown seed, but this may be remedied in a year or two when the new stock has become acclimatized.

With the object of getting some idea of the amount of disease in each variety, 50 tubers were selected at random and cut open. This year's results together with those of the three previous years are given in the following table:—

No.	Variety.	Number of diseased tubers.				Remarks.
		1909.	1910.	1911.	1912.	
1	2	3	4	5	6	7
1	King of Potatoes (1909)	...	10	12	Nil	4
2	King of Potatoes (1912)	...	...	...	...	Nil
3	Magnum Bonum (1908)	...	...	6	4	2
4	Magnum Bonum (1912)	...	...	...	...	6
5	Windsor Castle (1909)	...	Nil	16	12	4
6	Windsor Castle (1912)	...	...	...	...	4
7	British Queen (1909)	...	Nil	12	Nil	6
8	British Queen (1912)	...	...	...	...	4
9	Up-to-date (1909)	...	...	4	32	16
10	King Edward (1906)	...	Nil	18	8	4
11	Khasi Nainital (1900)	...	10	48	16	6
12	Khasi Round (1900)	...	Nil	4	8	6
13	Gladiator (1912)	...	...	...	...	8
14	Flour Ball (1912)	...	...	...	...	6
15	Harbinger (1912)	...	...	...	...	2
16	Imperator (1912)	...	...	...	...	22
17	Belle de Juliet (1912)	...	...	...	...	6
18	White City (1912)	...	...	...	...	10

The above figures cannot be taken as a conclusive test, but taken together with the amount of disease observed in the field they give some indication of the comparative disease-resisting power of the various varieties. It will be

seen that both King of Potatoes and Magnum Bonum grown from farm seed compare very favourably in this respect with the other varieties. King of Potatoes grown from seed imported from England in 1912 had no disease, but it is rather surprising that Magnum Bonum grown from seed imported in 1912 was worse diseased than that grown from farm seed. Last year the same thing was observed with regard to newly-imported Magnum Bonum, and that combined with the result obtained this year seems to indicate that the English stock of Magnum Bonum is deteriorating with regard to disease-resisting power. If such be actually the case, we shall be compelled to discontinue importing new seed of this variety. Fortunately, however, the old stock imported in 1908 is still fairly immune, and in addition we have a first-class-variety in King of Potatoes which has proved to be much superior to other varieties both in point of yield and in immunity from disease.

This year for the first time the tubers of each variety were sorted into three grades, *viz.*, large, seed size, and small. It is not proposed to give this mass of figures, but the general result showed that both King of Potatoes and Magnum Bonum grown from farm seed gave a very small proportion of small tubers, while the weights of the seed size and large were about equal. The majority of the tubers from King of Potatoes and Magnum Bonum imported in 1912 were 'seed size.' Khasi Nainital gave the largest proportion of large tubers.

8. These two experiments were combined on the same plots which were  $\frac{1}{10}$  acre in area. The variety planted was Magnum Bonum. The land was manured with 300 maunds cowdung and 10 maunds rape cake per acre.

Summer grown *versus* Winter-grown seed  
and Cut sets *versus* Whole sets.

The experiment was divided into two series. In one series the same weight of sets was planted, while in the other series the same number of sets was used. All the plots were duplicated.

The following tables give the results obtained :—

I. by using same weights of sets ;

II. by using same number of sets.

## I.—Same weight of seed, viz., 10 mds. per acre.

Kind of sets used.	Yield per plot.		Yield per acre.		Average yield per acre.	
1	2		3		4	
	Mds.	srs.	Mds.	srs.	Mds.	srs.
Cut sets (summer seed) ...	2	2	82	0	} 89	20
Ditto ditto ...	2	17	97	0		
Whole sets (summer seed) ...	4	14	174	0	} 170	20
Ditto ditto ...	4	7	167	0		
Cut sets (winter seed) ...	4	27	187	0	} 183	20
Ditto ditto ...	4	20	180	0		
Whole sets (winter seed) ...	5	20	220	0	} 222	0
Ditto ditto ...	5	24	224	0		

## II.—Same number of sets.

Kind of sets used.	Yield per plot.		Yield per acre.		Average yield per acre.	
1	2		3		4	
	Mds.	srs.	Mds.	srs.	Mds.	srs.
<i>First series.</i>						
Cut sets (summer seed) ...	3	5	125	0	} 103	20
Ditto ditto ...	2	2	82	0		
Whole sets (summer seed) ...	4	9	169	0	} 155	20
Ditto ditto ...	3	22	142	0		
<i>Second series.</i>						
Cut sets (winter seed) ...	5	3	203	0	} 200	0
Ditto ditto ...	4	37	197	0		
Whole sets (winter seed) ...	5	32	232	0	} 232	20
Ditto ditto ...	5	33	233	0		

The weight of whole sets was about 10 maunds per acre while that of cut sets was about 5 maunds.

The results set out in the above tables are strikingly uniform and show that whole sets give a much better output than cut sets, also that winter seed (*i.e.*, tubers produced from a second crop sown in August and harvested in November) is very much superior in yielding power to summer seed.

The results obtained in a similar experiment made last year indicate that winter seed is superior to summer seed and that whole sets are better than cut sets in the case of summer-grown seed only, cut sets giving a better outturn than whole sets in the case of winter-grown seed. It is difficult to account for this discrepancy, and the experiment will be repeated next season to decide the question.

Another experiment was made to compare the yielding powers of summer seed raised from summer seed, of summer seed raised from winter seed which was previously raised from summer seed, of winter seed raised from summer seed previously raised from summer seed, and of winter seed raised from summer seed which was previously raised from winter seed which was raised from summer seed. The results are set out in the following table, the "pedigree" of the seed being given in the first column.

The variety used was King of Potatoes, and the land was manured with 300 maunds of cowdung and 10 maunds of rape cake per acre. Whole sets were planted at the rate of 10 maunds per acre. The experiment was made in duplicate, the plots being  $\frac{1}{10}$  acre in area.

The results bear out our previous experience that winter seed is superior to summer seed, and also indicate that propagation twice a year, instead of being harmful as might have been expected, rather tends to be beneficial.

Kind of seed used.	Yield per plot.	Yield per acre.	Average yield per acre.
1	2	3	4
	Mds. srs.	Mds.	Mds.
Summer 1911 from summer 1910.	5 6	206	} 212
Ditto ditto ...	5 18	218	
Summer 1911 from winter 1910 from summer 1910.	3 32	152	} 170
Ditto ditto ...	4 28	188	
Winter 1911 from summer 1911 from summer 1910.	5 24	224	} 241
Ditto ditto ...	6 18	258	
Winter 1911 from summer 1911 from winter 1910 from summer 1910.	6 19	259	} 251
Ditto ditto ...	6 3	243	

9. The local method of planting potatoes is in beds about 7 feet wide separated from each other by furrows for drainage. The tubers are planted in holes about 18 inches apart, cowdung is placed on the top of the sets and the holes are then filled up level with the surface. Afterwards each plant is earthed separately. This method was compared with the ordinary European method of planting in drills on top of manure and earthing the plants in rows, the field eventually taking the form of alternate ridges and furrows. The seed rate was 10mds. per acre and the land was manured with the usual dressing of 300mds. of cowdung and 10mds. of rape cake per acre.

King of Potatoes (winter seed) was planted in series I and II and summer seed of the same variety in series III and IV.

The results are given in the following table :—

Method of planting.	Series I.	Series II.	Series III.	Series IV.	Total of 4 series.	
—	Per plot of $\frac{1}{32}$ acre.	Per plot of $\frac{1}{32}$ acre.	Per plot of $\frac{1}{32}$ acre.	Per plot of $\frac{1}{32}$ acre.	Four plots of $\frac{1}{32}$ acre.	Per acre.
1	2	3	4	5	6	7
	Mds. srs.	Mds. srs.	Mds. srs.	Mds. srs.	Mds. srs.	Mds. srs.
Local ...	5 20	6 2	4 19	4 25	20 32	208 0
Ordinary ...	6 9	6 5	4 20	4 31	21 26	216 10

The difference in yield, although slightly in favour of the ordinary method, is very small. In 1910 the local method gave better results than the ordinary method, while in 1909 and 1911 both methods came out about equal. It may, therefore, be concluded that for potato cultivation on a small scale both methods are equally advantageous. However on a large scale where ridging ploughs could be used for opening out drills and earthing, the ordinary European method would probably pay better on account of economy of labour.

10. From the 1911 crop 141 maunds of King of Potatoes and Magnum Bonum was sold to cultivators for seed. In 1912, 2.7 acres of King of Potatoes and 4.7 acres of Magnum Bonum were grown for seed, producing  $324\frac{1}{2}$  maunds of King of Potatoes and 466 maunds of Magnum Bonum. Of this, about 150 maunds of King of Potatoes and 350 maunds of Magnum Bonum is being sold to *bond fide* cultivators at a concession rate of Re. 1-8 per maund, while the bulk of the remainder has been planted for the production of winter seed, which will be sold to cultivators in the Spring after keeping sufficient seed for our next summer crop.

No difficulty has been found in inducing cultivators to purchase our seed, the bulk of that reserved for sale having already been sold. Instructions have been issued to purchasers to plant the improved varieties at once for the production of winter seed which will be planted next Spring. In this way the stock of the improved varieties should increase rapidly and a large area be planted in the Spring of 1913.

11. *Euchleana Maxicana* was sown on  $\frac{1}{5}$  acre in March 1911 and was harvested in October. The growth was stunted and the yield of green fodder was only  $12\frac{3}{4}$  maunds.

The following crops were put down in the Spring of 1912:—

I. *Langtylli*.—This is an indigenous grass which has proved to be a useful fodder crop. An additional area of about  $1\frac{1}{2}$  acres was planted and is doing well. An attempt was made to raise this grass from seed, but the germination was very unsatisfactory.

II. *Trydip grass*.—This is another good local fodder grass. About  $\frac{1}{2}$  acre was planted in March and is now well established.

III. *Alsike Clover*.—Seed obtained from Sutton and Sons (England) was sown in May on  $\frac{1}{10}$  acre plots:—

- (a) alone,
- (b) mixed with Langtylli grass,
- (c) mixed with Rye grass.

Germination was fairly good, but heavy rains in June practically destroyed it. Autumn sowing is being tried.



IV. *Italian Rye grass*.—This was also obtained from Suttons. Germination was good and the growth fair, but it is doubtful whether it will be able to compete with growth of indigenous weeds which spring up on cultivated land.

V. *Lupins*.—Seed obtained from England was sown in May. Germination was poor, but those plants which came up are growing well and there is some promise of success with this crop. The seed will be saved for sowing next year.

VI. *Sweet potatoes*.—About an acre of two local varieties was planted in June, and is doing well. The tubers will be stored for feeding to cattle in the winter.

VII. *Turnips*.—About  $\frac{1}{2}$  acre was sown in June, half in drills and half broadcast. The germination was good, but heavy rain destroyed most of the plants. Another sowing will be tried towards the end of the rains.

VIII. *Job's tears*.—This was sown mixed with soybeans and maize on about  $\frac{1}{2}$  acre. The mixed crop is growing well.

12. *Flax*.—Seed was obtained from the Fibre Expert, Eastern Bengal and Assam, and sown in July 1911 on  $\frac{1}{20}$  acre of land. Previous to sowing, rape cake was applied at the rate of 10 maunds per acre. Germination was good, but the growth was stunted. It eventually came into flower, but no seeds were formed.

*Soybeans*.—Trials of Darjeeling, Poona and Manchurian soybeans were made in 1911, and again this year. The Darjeeling variety does well, but both Poona and Manchurian are not at all promising.

*American Maize*.—Five varieties were sown in 1912. None of these have made such good growth as the local varieties. Seed of each variety will be saved for sowing next year with a view to acclimatization.

13. The following quantities of green fodder were ensiled in the autumn of 1911.

Fodder crops for silage and hay.				Maunds.
Maize ...	...	...	...	57
Raishan	...	...	...	398
Wild grasses	...	...	...	65
	Total	...	...	520

About 75 per cent. of this was recovered as good silage and fed to the cattle in the early Spring. This year about 7 acres of maize is being grown for silage, and about 7 acres of soybeans and 9 acres of raishan for hay.

14. The following table shows the number of cattle in the herd on 30th June 1912 :—  
Cattle breeding.

	Patna.	Bhutia.	Patna × Bhutia.	Patna × Bhutia × Patna.	Patna × Khasi.	Patna × Khasi × Patna.	Total.
1	2	3	4	5	6	7	8
Breeding Bulls ...	4	...	...	...	...	...	4
Bulls (3 years and above) ...	2	...	...	...	8	3	13
" (2—3 years) ...	7	...	...	...	...	4	11
" (1—2 " ) ...	3	...	2	1	...	...	6
Bull calves (under 1 year) ...	4	...	2	3	...	...	9
Cows ...	9	3	4	1	...	...	17
Heifers (2 years and above) ...	1	...	1	...	...	...	2
" (1—2 years) ...	1	...	...	1	...	...	2
" (under 1 year) ...	4	...	1	4	...	...	9
<b>Total</b> ...	<b>35</b>	<b>3</b>	<b>10</b>	<b>10</b>	<b>8</b>	<b>7</b>	<b>73</b>

In addition to the above there are 6 pairs of plough bullocks (2 Hindustani and 4 Khasi). The total number of cattle on the farm was therefore 85.

During the year 19 animals were born, *viz.* :—

4 Patna Bull calves.

1 Patna × Bhutia Bull calf.

4 Patna × Bhutia × Patna bull calves.

5 Patna heifer calves.

2 Patna × Bhutia heifer calves.

3 Patna × Bhutia × Patna heifer calves.

There were five deaths, viz. :—

- 1 Patna cow of old age.
- 2 Patna bull calves (one of foot-and-mouth disease).
- 1 Patna heifer also of foot-and-mouth disease.

The following were sold to Khasi cultivators :—

- 2 Patna bulls.
- 1 Patna × Khasi bull.
- 1 Patna × Khasi × Patna bull.
- 1 Patna × Bhutia bull
- and
- 2 Khasi bullocks.

During the year 4 Khasi plough bullocks were purchased from Jowai.

A pure bred Patna bull named "Akbar" was made over to a Goila at Umkhali, a village about 7 miles from the farm. No charge was made for the bull on condition that other bulls be excluded from the village. We have since discovered that this condition has not been carried out and that the bull is not being properly cared for. The bull therefore is being taken back to the farm, and we have decided that in future bulls will not be sent out free of charge since apparently people do not value the gift sufficiently to take reasonable care of it. As there is actually no difficulty in disposing of our bulls at a price, the practice of sending out bulls free of charge cannot be defended on any reasonable grounds.

The old Patna Bull "Taylor" was also lent out on similar terms, but the person to whom he was lent allowed him to get out of condition and the bull contracted foot-and-mouth disease. After recovery from this disease he was brought back to the farm.

In last year's report it is mentioned that owing to the absence of grazing and the difficulty of providing green fodder during the winter at Upper Shillong, a subsidiary grazing farm was opened at Sumer about 14 miles from Shillong on the Gauhati road on the grassy slopes of the lower hills. To this place all the big bull calves, heifers and dry cows were sent during the dry months January to March. There are several objections to this practice. It is

difficult to prevent our cattle from mixing with other cattle and thus contracting disease; also ticks are prevalent in the lower hills and the cattle suffer from their attacks a good deal. This year a very much larger quantity of silage will be made, and with this addition to the winter fodder supply we hope to be able to obviate the necessity of sending the cattle to Sumer.

An attack of foot-and-mouth disease broke out on the farm in September to October 1911. Practically the whole of the herd was attacked, but there were only two deaths.

15. With the object of improving the local breed of sheep an experiment was commenced in 1909 with a Dumba Ram and 5 Khasi ewes. By the 30th June 1910 the flock had increased to 15. In the following year two more Dumba Rams and 45 Khasi ewes were purchased and 7 cross-bred rams were sold, the flock on 30th June 1911 numbering 69.

On June 30th 1912 the total number of sheep on the farm was 136, made up as follows:—

Dum a rams	...	...	...	2
Khasi ewes	...	...	...	73
„ ewe lambs	...	...	...	7
„ ram lambs	...	...	...	10
Dumba × Khasi rams	...	...	...	4
Ditto ewes	...	...	...	6
Ditto ram lambs	...	...	...	13
Ditto ewe lambs	...	...	...	15
Dumba × Khasi × Dumba ram lambs	...	...	...	5
Ditto ewe lamb	...	...	...	1
				<hr/>
Total	...	...	...	136
				<hr/>

Forty-five Khasi ewes were purchased during the year and 67 lambs were born. One cross-bred ram was sold to a Khasi cultivator. The mortality was very heavy, there being no less than 44 deaths. An attack of foot-and-mouth disease

carried off 13 animals and one of the Dumba rams died from hoven. The remainder of the deaths occurred from other causes. The whole flock was sent down to Sumer for the months of January, February and March.

Samples of wool from the 1911 clipping were forwarded by the Director General of Commercial Intelligence to a Liverpool firm for valuation. The following report was received during the year:—

“*I.—Dumba Ram.*—White, a little strong in quality, irregular in staple, much short-grown and kemp, also much grease, some earth and burr. Value 5½d. per lb.

“*II.—Khasi sheep.*—Fawn and dark grey, coarse in quality, short in staple, much kemp and grease, some burr and earth. Value 2½d. per lb.

“*III.—Khasi × Dumba.*—White, a little strong in quality, fair staple, some kemp, much grease, a little burr and earth, a very saleable wool. Value 6½d. per lb.”

[*N. B.*—The wool represented by No. 3 is of a very saleable character.]

This report, showing as it does that the wool of the cross is much superior to that of the local breed and even somewhat superior to that of the Dumba, is decidedly encouraging.

16. During the 1912 season the following demonstrations were carried out by trained Khasi demonstrators on cultivators' holdings:—

- I. Spraying potatoes with Bordeaux mixture as a preventive of disease.
- II. Manuring winter rice with bone-meal.
- III. Grafting of fruit trees.
- IV. Rearing of European silk worms at the Roman Catholic Mission, Shillong.

These were carried out in 8 villages in the Khasi Hills. Each demonstration consisted of a sprayed plot and a control plot. The plots were sprayed twice with a total of 240 gallons of Bordeaux mixture per acre, 120 gallons at each spraying. The sprayed plots gave an increase in yield of from 7½ maunds to 27½ maunds per acre, the average being 12½ maunds per acre.

The people are now beginning to appreciate the benefit of spraying and a few persons have commenced spraying on their own account. For this purpose 13 seers of copper sulphate were sold to cultivators during the year. The chief obstacle to the spread of spraying is the cost of the sprayer which is more than the individual cultivator is willing to lay out. To get over this difficulty it is proposed to try to induce cultivators to combine for the purchase of sprayers. Next year in order to introduce the practice of spraying more widely we intend to send round about a dozen machines on hire, and payment for the use of the machines will be made on results, no payment being taken in cases where spraying has not had the effect of increasing the crop.

*Bonemeal for winter paddy.*—In former years this has been demonstrated with great success. As the result of these demonstrations many cultivators now collect bones and crush them roughly themselves for application to their paddy land, and 127 maunds of bonemeal was purchased by cultivators from the Agricultural Department during the present year. At present, we get the bonemeal from Calcutta and by the time it is landed in the Khasi Hills heavy freight charges have increased its cost to nearly Rs. 5 per maund. Nevertheless the demand for bonemeal is increasing rapidly and if the price could be lowered to say Rs. 3 per maund (the Calcutta price), there is no doubt but that most of the paddy land in the hills would be manured with it. In view of this we have under consideration a scheme for grinding bones at Shillong and selling the meal to the cultivators at the cost of the bones *plus* cost of grinding. This can only be done provided there is a sufficient annual supply of bones in the hills to warrant the initial expenditure on the grinding machinery, and an enquiry is being made to ascertain the approximate quantity of bones annually available. This year only two bonemeal demonstrations were attempted owing to shortage in staff. The results will be given in next year's report.

During the year two fieldmen demonstrators were sent out to instruct owners of orchards in grafting. Numerous villages were visited by the demonstrators and 410 grafts were made, of which 253 were pears, 47 were apples and 110 were apricots.

Grafting of fruit trees.

For the past 8 years European silkworms have been reared at the fruit garden, but this year an arrangement was made with the Roman Catholic Mission, Shillong, whereby the rearing should be done on their premises. The Agricultural Department supplied seed, apparatus and mulberry leaves and also a trained apprentice for supervision of the work which was done by the orphan boys of the Mission under the tuition of the apprentice.

The following varieties of seed were reared :—

	Oz.
French Var (obtained in October 1911) ...	1½
„ Cellular (obtained in October 1911) ...	¼
„ Var (raised from last year's rearing ...	¼
Italian yellow ( ditto ditto ) ...	¼
Total ...	2½

The seed was incubated by putting it near the stove in a temperature of 60°F., gradually rising to 75°F. The worms began to hatch on March 17th and to spin on May 11th. The average heat of the rearing room was 55°F. in the morning, 75°F. at noon and 60°F. in the evening. Trays were cleaned on alternate days. The worms were fed 4 times a day from the time of hatching till the 3rd moulting, and 3 times a day from then until spinning time.

The worms thrived well and commenced spinning 54 days after hatching. The mortality from disease was very small.

The actual yield of green cocoons was as follows :—

	Mds.	sts.
French Var (imported) ...	1	30
„ Cellular (imported) ...	0	33
French Var (local) ...	0	12
Italian yellow (local) ...	0	8
Total ...	3	83

The weight of waste cocoons was 1 seer 12 chhataks and that of floss 10 chhataks.

The green cocoons were killed and dried in an oven at a temperature of 160°F. The figures given in the following table are the average measurements of 25 cocoons of each variety selected at random.

Two hundred cocoons of each variety have been preserved for seed.

No.	Variety.	Average dimension.		Average weight of green cocoons, Grammes.	Average weight of each shell of silk, Grammes.	Percentage of shell on weight of green cocoons.
		Length Millimetres.	Width Millimetres.			
1	2	3	4	5	6	7
1	Italian yellow, Shillong ...	38.408	17.980	1.857	.25	13.469
2	French Var, Shillong ...	34.29	16.986	1.857	.290	15.616
3	French Var. (imported) ...	35.438	17.716	1.75	.287	15.257
4	Var cellular (imported) ...	34.687	17.140	1.875	.25	13.462

17. The receipts of the year amounted to Rs. 2,959-1-0, of which Rs. 445-12-3 was obtained by the sale of milk, Rs. 672-2-6 by the sale of potatoes, and most of the balance by sale of cattle. Some milk accounts were outstanding at the end of the year.

The expenditure amounted to Rs. 17,983-3-8 and included Rs. 2,483-14-4 for establishment and Rs. 859-13-3 for capital charges. These amounts are inclusive of the receipts and expenditure of the fruit garden which has hitherto been managed as a joint concern with the Upper Shillong farm.

The cost of cattle and sheep breeding was as follows:—

Purchased foods	...	...	Rs. a. p.
Value of farm produce fed	...	...	2,616 5 9
Wages of attendants	...	...	329 9 9
Miscellaneous	...	...	1,720 0 9
	...	...	240 0 0
<b>Total</b>	...	...	<u>4,906 0 3</u>



The proceeds were Rs. 445-12-3 by sale of milk and  
Rs. 1,190 by sale of cattle.

A. G. BIRT,

*Deputy Director of* ●  
*Agriculture, Assam.*

SHILLONG;  
*The 15th September 1912.*

# ANNUAL REPORT

ON THE

## AGRICULTURAL EXPERI- MENTS AND DEMONS- TRATIONS

IN

### ASSAM.

FOR THE

YEAR ENDING THE 30TH JUNE 1913.



SHILLONG:

PRINTED AT THE ASSAM SECRETARIAT PRINTING OFFICE.

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## PREFACE.

Mr. A. A. Meggitt, Agricultural Chemist, Dacca, made all the sugarcane analyses and compiled Tables I to VII. I am also indebted to him for the paragraph on "Soil Investigations." A note by Mr. Meggitt on soil acidity and the use of lime is printed as an appendix.

A. G. BIRT,  
*Deputy Director of Agriculture,*  
*Assam.*

15th September 1913.

**ANNUAL REPORT OF THE JORHAT AGRICULTURAL  
EXPERIMENT STATION FOR THE YEAR ENDING  
JUNE 30TH, 1913.**

This station was established in the beginning of the year 1906 and is intended principally for sugarcane work.

**Introduction.** It is situated about 3 miles south of Jorhat town in Sibsagar district, Assam Valley. The original area was about 35½ acres, of which 1.7 acres is *hola* or ravine land, and the remainder high land which was under grass and scrub jungle at the time of acquisition. An additional area of 20 acres, mostly high land, was acquired last year; this is gradually being brought under cultivation.

2. The soil of the high land is a reddish sandy loam of the old alluvium, lying on a hard greyish yellow sub-soil. Where the conditions have not been improved by cultivation, the soil is extremely shallow, varying from only 3 to 6 inches in depth.

The following report by Mr. A. A. Meggitt, Agricultural Chemist, Dacca, is given *in toto* :—

*Report on Analysis of Jorhat Farm Soil.*

Chemical.	Surface soil.	Sub-soil.
	Laboratory No. 5.	Laboratory No. 5(a).
1	2	3
<i>Soluble in hydrochloric acid with 12 hours' digestion at 100°C.</i>	Per cent.	Per cent.
Phosphoric acid (P <sub>2</sub> O <sub>5</sub> ) ... ..	0.25	0.20
Potash (K <sup>2</sup> O) ... ..	0.115	0.135
Lime (CaO) ... ..	0.154	0.144
Magnesia (MgO) ... ..	0.166	0.148
<i>Soluble in 1 per cent. citric acid with 7 days' digestion.</i>		
Phosphoric acid ... ..	0.008	0.008
Potash ... ..	0.007	0.011
Loss on ignition (organic matter and combined water)	3.26	1.84
Nitrogen ... ..	0.114	0.051
Calcium carbonate ... ..	0.018	0.018
Re-action ... ..	Acid	Acid

*Physical constants.*

1	Hygroscopic capacity.	Maximum water-saturation capacity.		Minimum water-saturation capacity.		Moisture in air dry soil.
		Per cent. of water in saturated soil by weight.	Per cent. of water in saturated soil by volume.	Per cent. of water by weight.	Per cent. of water by volume.	
2	3	4	5	6	7	8
Surface soil	3.2	31.3	50.5	11.2	43.9	1.3
Sub-soil	...	36.0	53.6	7.2	9.1	1.19

*Remarks.*

" These analyses agree quite well generally with some others made some years ago by the Imperial Agricultural Chemist.

These samples are acid in re-action, and the total lime present in all combinations, as well as the carbonate of lime, is quite deficient in quantity.

Carbonate of lime has an enormous influence on a soil's welfare—chemically, physically, and bacteriologically.

Its effect on soil biological processes are in the right direction, and very great; it also influences the texture of soils in a remarkable way, and is active in bringing into use the reserves of dormant plant food. Its presence in fair amount also ensures the most economical effect of any manuring given. Its absence forbids the use, for most cropping, of certain kinds of manures, unless it be first resorted to.

" Any upland soil containing such small amounts of total lime and lime carbonate as are here present will most certainly respond markedly in the case of most cropping to applications of lime.

" The amount of organic matter is probably greater than obtains in many Indian soils, but there is no doubt that a light soil of this character will be much improved in many ways by an increase in the amount of humus. A good deal of the organic matter present is of a doubtful character, and consists very probably of very old residues of little value; it is the presence and active decay of comparatively recent additions of organic matter which puts life into a soil.

The percentage of nitrogen present in the surface soil is what would normally be considered a fair one, but in view of the absence in anything like adequate quantity of carbonate of lime, conditions for nitrification are probably not as favourable as they might be by a long way, and an increase in the amount of nitrogen is indicated as desirable.

Of potash there is no dearth, and there would seem to be no immediate need for potash manuring.

Regarding phosphoric acid, these samples show a deficiency both in total as well as available supplies. There is thus a 'real' as opposed to a mere temporary lack in respect of this element of plant food.

This lack of phosphoric acid is further aggravated by the absence of sufficiently large amounts of lime carbonate and humus, high percentages of which may, and often do offset a smaller percentage of phosphoric acid.

An acid condition of soil, besides being harmful in itself, very often brings about a more rapid depletion of the soil's stock of phosphoric acid, in consequence of which most soils of a decidedly acid character are found to be lacking in this element, and to respond to its suitable application.

Turning to the physical constants, the hygroscopic capacity is low, and about what one would expect for this class of soil. It means that only water which is in excess of about 3 per cent. is available for crops, and plants are able to reduce the soil moisture content to somewhere about this figure before they begin to wilt. The top 6 inches of soil even during the cold weather normally contains a good deal more moisture than 3 per cent., when under a close standing crop, so that usually there is sufficient water for the crops' requirements. "



4

"As regards maximum saturation capacity, these soils agree quite well with quoted figures for similar soils in Europe, and suggest that the optimum proportion of water for the growth of the plant is about 13.16 per cent. A recent determination of soil moisture in the surface 6 inches of the soil of this farm in August some few hours after rain gave 17 per cent. water. Soil moisture conditions are therefore probably extremely favourable for growth during the rainy season.

The figures for minimum saturation capacity are much lower than those cited (*Hall, The Soil, page 69*) for similar soils in Europe, and this is probably due to the lower content of humus which obtains in our soils. This is an extremely important figure in gauging a soil's power to retain a reserve of moisture for crops during dry periods.

The sub-soil is worse in this respect than the surface layer, suggesting that the incorporation of organic matter, if it can be buried sufficiently deep, will have a very great ameliorating effect indeed.

The sub-soil is capable of very great improvement indeed, as the figures show, but it would probably be immediately disastrous to work it so deeply as to bring any considerable amount to the surface at once.

The growth of deep-rooting legumes as green crops will assist materially, but if the sub-soil could be stirred occasionally while at the same time the surface cultivation is gradually deepened so that green crops may be more deeply buried, a greater depth of surface soil will result, which on this farm is very much to be desired.

I am convinced that for cane cultivation, until the surface soil has been deepened and the amount of humus increased, it is of little use attempting manurial experiments on cane with artificial manures. No amount or combination of the latter can ever make up in the case of a crop like sugarcane for loss of fertility due to shallow cultivation and lack of humus."

3. The farm is equipped with a godown, combined office and rest-house, quarters for Farm Superintendent and two apprentices and a cattle shed with brick walls and a corrugated-iron roof. A three-roller cane mill 12 inches × 18 inches driven by a 9 B. H. P. Hornsby oil engine was installed in 1911. During the year quarters for the Fieldman clerk were built at a cost of Rs. 600.

Buildings and machinery, etc.

4. The rainfall recorded during the growth of the crops referred to is given in the following table together with the normal rainfall:—

Month.	Actual rainfall, in inches.	Normal rainfall, in inches
1	2	3
1912, April ... ..	10.67	8.54
„ May ... ..	12.26	9.26
„ June ... ..	9.51	11.36
„ July ... ..	27.43	14.76
„ August ... ..	10.66	15.15
„ September ... ..	6.03	9.18
„ October ... ..	5.85	4.07
„ November ... ..	1.19	0.69
„ December ... ..	0.24	0.52
1913, January ... ..	0.80	0.93
„ February ... ..	4.11	1.32
„ March ... ..	2.62	3.90
Total ... ..	91.37	79.68
„ April ... ..	22.47	8.54

• The rainfall was ample and well distributed. The rain in February interfered somewhat with the harvesting of the ratoon cane.

Experimental work.

5. The work of previous years was continued and extended.

It mainly consisted of:—

- I. Sugarcane experiments.
- II. Soil improvement investigations.
- III. Trials of crops new to the locality.

Varieties : ratoon  
cane. 6. The following varieties planted in Block B in 1911 were ratooned:—

Striped Mauritius	} ¼ acre plots.
B 147.	
B 376.	
B 1753.	

B 208.	} 1/10 acre plots.
Striped Tana	
Yellow Tana.	
Magh.	
Kheri.	

The results of the first crop were given in last year's annual report. After harvesting the 1912 crop the trash remaining on the field was burnt and all pieces of diseased cane which remained were collected and removed. The land was then hoed. As in previous years the crop was earthed twice, and received a dressing of 20 maunds of rape cake per acre, half of which was applied at the time of first earthing and half at the second earthing.

Beyond the occasional removal of dead leaves and badly diseased canes no other cultivation was given.

The local variety Magh, as usual, ratooned so badly that the plot was not worth crushing. The results of the remaining varieties are set out in Tables I. and II. Table I shews the analyses of the juice and Table II the weights of cane, juice, and sugar, etc., per acre.

TABLE I.  
RATOON, 1912-1913.  
*Juice.*

Serial No.	Variety	Area weighed and analysed.	Cane sugar.	Invert sugar.	Total sugar.	Glucose ratio.	Total solids.	Purity coefficient.	Remarks.
1	2	3	4	5	6	7	8	9	10.
1	Striped; Mauritius	½ acre...	Per cent. 16.39	Per cent. 0.51	Per cent. 16.90	8.11	Per cent. 17.07	92.7	High purity juices of very good quality.
2	B 376	... ½ "	15.32	0.61	15.93	8.98	16.75	91.4	
3	B 203	... ½ "	15.49	0.84	16.33	8.42	17.08	90.7	
4	B 147	... ½ "	16.40	0.53	16.93	8.23	17.93	91.4	
5	Yellow Tana	... ½ "	13.63	1.25	15.09	9.11	16.56	83.8	
6	Striped "	... ½ "	12.84	1.09	14.48	12.39	15.70	81.8	
7	B 1753	... ½ "	9.67	1.97	11.94	20.37	12.76	75.18	
8	Kheri	... ½ "	11.29	1.88	13.17	16.65	14.64	77.1	

TABLE II.  
RATOON, 1912-1913.  
*(Figures are per acre.)*

Serial No.	Variety.	Area weighed.	Yield of cane per acre.	Yield of juice per acre.	Percentage juice on cane.	Total sugar per cent. on juice.	Total sugar per acre in juice.	Total cane sugar in juice (St. cross).	Remarks.
1	2	3	4	5	6	7	8	9	10
1	Striped Mauritius	½ acre	Lbs. 55,907	Lbs. 36,920	66.0	16.90	6,240	6,051	Badly diseased and lodged.
2	B 376	... ½ "	61,388	43,140	67.5	15.93	6,600	6,347	Badly lodged, not diseased.
3	B 203	... ½ "	72,160	47,090	65.2	16.33	7,690	7,294	Badly lodged, some borer and disease present.
4	B 147	... ½ "	69,120	47,016	68.0	16.93	7,950	7,710	Excellent cane, topped for sets, reducing yield slightly.
5	Yellow Tana	... ½ "	72,380	45,120	62.3	15.09	6,809	6,240	A finer variety than the Striped Tana.
6	Striped "	... ½ "	74,784	46,900	62.7	14.43	6,767	6,023	Coarse fibrous cane; gives much trouble at the mill.
7	B 1753	... ½ "	55,609	35,088	63.1	11.64	4,084	3,570	Badly diseased.
8	Kheri	... ½ "	82,000	48,160	58.3	13.17	6,346	5,440	

This year all the varieties, with the exception of Striped Mauritius and Kheri, gave less percentage of total sugar in juice than last year. With regard to total sugar per acre, B 147, B 208, Kheri and the Tanas shew a very considerable increase over last year's figures; B 376, owing chiefly to lodging, gives over 2,000 lbs. less total sugar than last year, and B 1753 is also down on last year's figures, although not to the same extent, while Striped Mauritius is about the same as last year.

The four varieties B 147, B 208, B 376 and Striped Mauritius give juices of much higher purity than any of the other varieties. B 147, with a juice purity co-efficient of 91.4 and a yield of nearly lbs. 8,000 of total sugar per acre, gives the best results this year, closely followed by B 208, a variety which some years ago we very nearly decided to drop altogether, as it was doing so badly. B 1753 is the worst of all both with regard to quality of juice and yield of total sugar per acre. This variety has been going from bad to worse during the last few years, and in view of the fact that it was impossible to get sufficient sound cuttings to plant even a small area, we decided last year to exclude it from future experiments.

Varieties: plant cane. 7. The following varieties were grown on Block A:—

B 147.	}	$\frac{1}{4}$ acre duplicate plots.
B 376.		
Striped Mauritius.		
B 208.	}	$\frac{1}{20}$ acre plots.
Yellow Tana.		
Magh.		
Kheri.		

B 1753 was excluded for the reasons stated in paragraph 6. Striped Tana was also excluded as being similar to the yellow variety but inferior as regards quality of juice, and at the same time being so thick and coarse that milling was difficult.

This block of land carried a crop of cane in 1908-09 which was ratooned on part of the area in 1909-10. The land was in wretched condition at this time, in fact the worst land on the farm. A dressing of 50 maunds of slaked lime was applied in 1910 after the removal of the ratoon crop, which was followed by *aus* paddy. The following cold weather it carried a poor crop of *matikalai*. In 1911 it was green manured with cowpeas and left fallow during the cold weather of 1911-12.

Owing to the poor results obtained with cane on this block before, it was with grave misgivings that we decided to plant cane again in 1912, but we had no choice since there was no other land available at the time.

In order to give the crop the best possible chance, the trenches were opened out at the end of January about two months before planting the cane, instead of just before planting as in former years, and the sub-soil at the bottom of the trenches was turned over to a depth of about 6 inches. Subsequently the haulms of a crop of groundnuts, which had recently been harvested, were thrown into the trenches and incorporated with the sub-soil. The sub-soil in the trenches was thus exposed to weathering for about two months, and in addition had a considerable amount of organic matter added. Another innovation was tried in the case of manuring. Instead of ploughing in 500 maunds of cowdung before planting as was the practice hitherto, 200 maunds of the cowdung was applied in the trenches at planting time, and the remainder was given in two doses, one at the time of first earthing and the other at the second earthing. Subsequent cultivation was as usual, consisting of stripping and removal of badly diseased canes periodically. As will be readily gathered from the following tables, the results obtained fully justified the new methods of cultivation, the crop being far ahead of anything hitherto obtained on the farm.

TABLE III.  
PLANT CANE, 1912-1913.

*Juice.*

Variety.	Area weighed and analysed.	Cane sugar.	Invert sugar.	Total sugar.	Glucose ratio.	Total solids.	Purity coefficient.	Remarks.
1	2	3	4	5	6	7	8	9
		Per cent.	Per cent.	Per cent.			Per cent.	
B 147 (plot 1)	... ½ acre	16.85	0.52	17.37	3.08	18.43	91.4	Plot 1 was laid by storm and had to be harvested before it was ripe.
B 147 (plot 4)	... ½ " "	17.37	0.3	17.67	1.73	18.7	92.9	
B 376 (plot 2)	... ½ " "	16.82	0.38	17.18	2.14	17.9	93.97	
B 376 (plot 5)	... ½ " "	15.08	0.45	15.53	2.98	16.3	92.5	Plot 5 was badly laid by storm and very much damaged by parrots and became overripe before it could be crushed on account of bad weather.

TABLE III—concl'd.

Variety.	Area weighed and analysed.	Cane sugar.	Invert sugar.	Total sugar.	Glucose ratio.	Total solids.	Purity coefficient.	Remarks.
1	2	3	4	5	6	7	8	9
* Striped Mauritius (plot 3).	$\frac{1}{2}$ acre	Per cent. 16.84	Per cent. 0.39	Per cent. 17.23	2.31	17.85	Per cent. 94.3	
B 208 ... ..	$\frac{1}{10}$ " "	18.97	0.20	19.17	1.05	19.70	96.3	Great improvement in this cane.
Yellow Tana ... ..	$\frac{1}{10}$ " "	15.65	0.59	16.24	3.77	17.65	88.6	
Magh ... ..	$\frac{1}{10}$ " "	13.23	0.90	14.13	6.80	15.4	85.9	
Kheri ... ..	$\frac{1}{10}$ " "	13.23	1.23	14.46	9.30	15.75	84.0	

\* Result's of only one plot are given, as there were not sufficient sets to plant a full duplicate plot, and the land was inferior in that part of the field.

TABLE IV.  
PLANT CANE, 1912-1913.

Variety.	Area weighed and analysed.	Yield of cane per acre.	Yield of juice per acre. lb.	Per cent. juice on cane.	Total sugar per cent. on juice.	Total sugar per acre in juice.	Total cane sugar per acre in juice. (Sucrose.)	Remarks.
1	2	3	4	5	6	7	8	9
B 147 (plot 1) ... ..	$\frac{1}{2}$ acre.	Lbs. 74,736	Lbs. 51,376	68.7	17.37	8,924	8,656	Topped for sets. Excellent cane.
B 147 (plot 4) ... ..	$\frac{1}{10}$ "	70,332	47,096	67.0	17.67	8,322	8,180	Ditto ditto.
B 376 (plot 2) ... ..	$\frac{1}{10}$ "	72,856	49,568	68.0	17.18	8,515	8,337	Ditto ditto.
B 376 (plot 5) ... ..	$\frac{1}{10}$ "	68,712	46,684	68.2	15.53	7,282	7,070	Badly damaged by storms and parrots.
Striped Mauritius (plot 3)	$\frac{1}{2}$ "	70,968	49,328	69.5	17.23	8,500	8,307	Excellent cane. Much better than for past few years.
B 208 ... ..	$\frac{1}{10}$ "	58,520	38,160	65.2	19.17	7,315	7,240	Better cane than usual. This variety is undoubtedly improving.
Yellow Tana ... ..	$\frac{1}{10}$ "	62,160	39,600	63.7	16.24	6,431	6,197	
Magh ... ..	$\frac{1}{10}$ "	62,320	42,160	67.6	14.13	5,957	5,777	
Kheri ... ..	$\frac{1}{10}$ "	75,300	45,940	61.0	14.46	6,643	6,078	

The great feature of this year's results is the very high yield<sup>s</sup> of cane and sugar per acre of the four varieties B 147, B 376, B 208 and Striped Mauritius. Kheri also gives a big yield of cane, but owing to the low percentage of juice on cane and the inferiority of its juice, the yield of sugar per acre is very much less.

B 147 (plot 1) gave practically 4 tons total sugar per acre in extracted juice, and 3.86 tons sucrose. This is the highest yield we have ever had, and would probably have been greater had not the crop been heavily laid by a severe storm before it was ripe, necessitating premature harvesting. The plot was topped for sets, this also reducing the yield slightly.

The average yield of sucrose per acre for the four varieties B 147, B 376, B 208 and Striped Mauritius works out at just over 3.5 tons per acre.

The juice of all these varieties is rich in sucrose, poor in glucose, and of very high purity.

The excellent results obtained this year are probably due to a very large extent to—

- (a) improved drainage ;
- (b) weathering of sub-soil in trenches ;
- (c) direct application of manure to the crop ;
- (d) comparative freedom from borer, probably due to the fact that, for the last two years, the trash from both plant and ratoon cane has been spread over the fields and burnt.

8. This was laid down in Block B in 1911 on four  $\frac{1}{16}$  acre plots, the following methods of planting being compared :—  
 Planting experiments:  
 Ratoon cane.

*Plot I*—Rows 3' apart, sets planted 2' apart in row.

„ *II*— Ditto sets planted end to end.

„ *III*—Rows 4' apart, ditto ditto.

„ *IV*— Ditto and 1' wide, sets planted alternately.



The results of the first crop are given in last year's report. The ratoon crop was treated in the same way as in the variety experiments. The results are given in the following table:—

TABLE V.

RATOON, 1912-1913—PLANTING EXPERIMENT.

*Striped Mauritius  $\frac{1}{10}$ th acre plots.*

	Cane per acre.		Juice per acre.	Per cent. juice on cane.	Cane sugar in juice.	Invert sugar in juice.	Total sugar in juice.	Glucose ratio.	Total solids on juice.	Purity coefficient.	Total sugar per acre.	Remarks.
1	2	3	4	5	6	7	8	9	10	11	12	
	Lbs.	Lbs.		Per cent.	Per cent.	Per cent.		Per cent.		Lbs.		
Plot 1	65,340	40,570	62.1	15.01	0.92	15.93	6.13	16.54	90.7	6,463	All badly diseased.	
" 2	60,800	37,260	61.3	15.00	0.92	15.92	6.13	16.71	89.7	5,932		
" 3	56,320	38,390	68.1	15.12	0.83	15.95	5.40	16.68	90.6	6,123		
" 4	62,600	40,820	65.2	15.19	0.84	16.03	5.53	17.05	89.1	6,548		

All the plots were badly diseased and this seriously detracts from the value of the experiment. There is very little to choose between any of the plots. The increased number of sets in plots 2, 3 and 4 give no advantage over the usual number (7,260 per acre) in plot 1.

9. This was laid down in 1912 in Block A. Cultivation and manuring was the same as for the variety experiments in the same block. There were three plots each  $\frac{1}{8}$  acre in area, the distance between the rows being 3, 4 and 5 feet, respectively. An equal number of sets was planted in each row. The variety planted was B 376. The results are set out in Tables VI and VII.

TABLE VI.  
Plant cane, Planting Experiment, 1912-13.

B 376.		Area plot.	No. of rows.	Width apart of rows.	Sets per row.	Weight of cane produced per row.	Number of canes produced per row.	Remarks.
1	2	3	4	5	6	7	8	
Plot 1	...	$\frac{1}{2}$ acre	20	3 ft.	45	Lbs. 469	117	Each row had same number of sets. The distance between the rows, and hence the number of rows per plot was the only variant.
" 2	...	$\frac{1}{2}$ "	15	4 ft.	45	544	130	
" 3	...	$\frac{1}{2}$ "	12	5 ft.	45	598	145	

TABLE VII.  
Plant cane, Planting Experiment, 1912-13.

B 376.		Cane per acre.	Juice per acre.	Juice on cane.	Cane sugar in juice.	Invert sugar in juice.	Total sugar in juice.	Glucose ratio.	Total solids in juice.	Purity co-efficient.	Total sugar.	Remarks.	
1	2	3	4	5	6	7	8	9	10	11	12		
Plot 1 ( $\frac{1}{2}$ acre)	...	Lbs. 75,024	Lbs. 49,176	Per cent. 65.5	Per cent. 16.51	per cent. 0.35	Per cent. 16.86	2.12	Per cent. 17.55	94.0	8,390	Same number of sets in each row in all three plots. Plot 1 has some 7,300 sets per acre.	
Plot 2 ( $\frac{1}{2}$ acre)	...	65,304	43,472	66.5	16.59	0.31	16.90	1.87	17.60	94.2	7,347		Plot 2 had some 5,400.
Plot 3 ( $\frac{1}{2}$ acre)	...	57,400	40,176	69.9	16.25	0.32	16.57	1.97	17.25	94.2	6,687		Plot 3 had some 4,320.

As regards quality of juice there is practically no difference between the three plots.

The figures show clearly that, with the same spacing of sets in the rows, the wider the rows are apart the better the tillering and the bigger the weight of cane per row.

However, it appears that though the above is true, yet the number of sets per acre cannot be reduced below about 7 to 8 thousand, *i.e.*, the extra tillering due to wider planting does not fully compensate for the reduction of the number of sets.

Taken in conjunction with last year's plant-cane planting experiment results, it seems very probable that it will be possible to obtain full crops with rows 4 or 5 feet apart provided the sets are so spaced in the row as to give 7 to 8 thousands sets per acre. For cultivation with machinery wider planting than 3 feet apart would be necessary in order to give sufficient space for interculture. Probably from 4 to 5 feet between the rows would be sufficient. The point to be decided is the number of sets required in the wider rows to give the maximum crop.

10. The chief point to be noticed is the very heavy yields of cane Sugarcane. General and sugar per acre of B 147, B 376, B 203 and remarks. Striped Mauritius. In 1909 and 1910 these varieties, amongst others, were grown on this area (Block A) and the 1st crop (1909) was so poor that it was not thought worth while harvesting experimentally. This was not for want of direct manuring, as the crop received 400 maunds of cowdung and 24 maunds of rape cake per acre. The ratoon crop from this area was harvested in 1910 and the results are given in the Annual Farm Report for that year.

A comparison of the results is instructive. In 1910 Striped Mauritius gave about 4,000lbs., B 147 3,200lbs. and B 376 2,700lbs. of sugar per acre, as against 8,500lbs., 8,900lbs. and 8,500lbs., respectively, in 1913.

In the case of Striped Mauritius and B 147 this year's yield is more than double that of 1910, while for B 376 it is more than treble.

The explanation of this is probably that since the harvesting of the ratoon crop in 1910—

- (a) the land has been limed,
- (b) the land has been green-manured,
- (c) the sub-soil in the trenches was weathered before planting.

Another factor influencing the yield in 1913 is that the sets were very carefully selected for planting and hence disease was reduced to a minimum.

On the whole the results obtained this year, combined with those obtained in former years, indicate that in Assam it is possible to grow heavy crops of sugarcane of very high quality. At Jorhat we are working on a very poor soil with shallow cultivation. If from 3 to 4 tons of sugar per acre can be obtained by our more or less primitive methods on a poor soil, what results should be obtained on a good soil with deeper and more up-to-date methods of cultivation? This problem we hope to solve within the next three or four years, when it is proposed to grow a large area of cane by steam-tackle cultivation.

11. The soil and manurial work described in last year's report\* has been continued, and in some directions amplified and extended.

Soil Investigation.

This work forms part of a general investigation of special soil conditions obtaining in tracts of heavy rainfall, where for various reasons a dangerous degree of soil acidity is fairly general.

Much valuable information has already been obtained as to the special characteristics of these soils, and the measures adopted for their amelioration are proving very promising.

The work is being tackled principally from the point of view of the soil's requirements for lime, organic matter, and phosphoric acid, for general cropping, and involves a study of the principles underlying their most successful and economical use and supply.

Of special importance under our conditions is the form in which certain manures find their most suitable application.

Thus, work during the year has shown that the use of basic insoluble phosphates is generally attended with markedly beneficial results on cropping, while where acid superphosphate is used the effect is very small unless used in conjunction with lime. There is good reason to believe that its continued use without lime can result in nothing but definite injury to the soil.

Again, Sulphate of ammonia proved absolutely toxic to a crop of oats in the cold weather in the absence of previous liming.

*General.*—Continued observations on the comparative growth of various crops on limed and unlimed areas confirm fully the statements made in last year's report as to their much greater luxuriance on the former.

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\* Annual Report of the Jorhat Experiment Station, year ending 30th June 1912.

Four new crops come under observation during the year, *e.g.*, barley, soy-beans; also dhaincha and sunn hemp as green manures.

Barley and soy-beans were sown on both limed and unlimed land; both crops did extremely well on the former, while on the unlimed area the barley early succumbed, the soy-beans ripening off a very small crop only.

Sunn hemp and dhaincha were grown only on limed soil; both made very good crops, sunn hemp being the better. There should be a very useful field for sunn as a green manure crop on the lighter soils of Assam.

Cowpeas for green-manure, and earthnuts were both sown on limed and unlimed areas. In either case they did much better on limed land making more luxuriant crops, darker green in colour, and entirely smothering the weeds.

Again, a catch green manure crop of cowpeas, sown at the end of July after harvesting *aus* paddy, in one of the experimental blocks, made within 7 weeks growth a 10-anna crop on the limed plot, and only a 4-anna one on the unlimed side. Previous to this both plots had been cropped for 3 years without other manure.

The cane crops obtained during the year bear further strong evidence as to the soundness of our soil policy, which in addition to the direct manuring of the cane, include the use of lime and the regular inclusion of green-manuring in the rotation, coupled with good cultivation.

The average yields of cane for our three best varieties, each grown on duplicate  $\frac{1}{4}$  acre plots, was 31.9 tons per acre, being just about three times the crop obtained in 1908-09, the last year that the self same area came under cane, when it was by the way directly manured much more heavily than during the year under report.

The gradual increase in crop production is being attended by steadily improving soil conditions, rather than by a process of gradual soil impoverishment, and this is as it should be of course.

*Experimental—Block G.*—This experiment commenced in 1909, and described on pages 19-21 of last year's report was continued, this being its 4th year. It was cropped as for last year, *viz.*, *aus* paddy followed by *matikalai*, oats, gram and mustard in the cold weather.

A catch crop of cowpeas for green-manure taken after the *aus* paddy, on the limed side made a 10-anna crop, only a 4-anna crop resulting on the unlimed area.

No manure was applied to either side. During the cold weather, as in former years, of the four crops sown, none survived the seedling stage on the unlimed side.

On the limed area with the exception of mustard, the other crops, *e.g.*, *matikalai*, oats, gram, were not so good as in the previous years. Oats made a medium crop, *matikalai* a poor one, while the gram, starting well, gradually succumbed as the cold weather wore on.

This may be due to exhaustion of plant food by four years' continuous cropping without any manure, or to the fact that the supply of lime is becoming exhausted, or both. It received lime at the rate of 50 maunds per acre in 1909; two years later the soil was slightly alkaline to 6 inches, below that it was acid. In 1912, the first three inches only was faintly alkaline, below that depth was acid again.

There is then good evidence that acid conditions are gradually being re-established, and the crop of gram in particular bore striking evidence to that effect, gram being a crop which requires a good deal of lime.

*Block C—Experiment.*—This experiment, commenced in 1911 and described on pages 23 to 32 of last year's report, was continued in its second year.

The plots which had only 10 maunds lime per acre in 1911, received a second dressing of 10 maunds this year also.

None of the other plots received further lime. Cross-dressings of bone-meal and cowdung were applied as in the first year of the experiment.

The cropping during 1912 was:—

Rains	...	...	...	Jowar, for fodder.
Rabi	...	...	...	Mustard.

#### *Field observations during growth.*

*Jowar.*—This crop germinated badly, owing to poor seed, all over either block.

On the two non-limed areas the seedlings died out completely at a very early stage, even where cross-dressed with bone-meal, or cowdung, or both.

The outstanding feature throughout the growing period of this crop was the enormous influence of lime, the effect being proportional to the dressing; thus the growth on the 60 maunds lime plots was much better than that on the 30 maunds plots, which was not the case with the preceding crop of oats.

On the green-manured block the crop throughout was stronger, darker green, and healthier looking than on the non-green-manured area; still, where not limed, there was not a vestige of *jowar*.

The effect of bone-meal was not very marked during the growing period, except on the green manured block when used along with cowdung and the larger lime dressings.

The effect of cowdung was more evident than that of bone-meal, but again was most marked where applied with the larger lime doses.

It is to be noted that even within the limits of the same sub-plot, there occurred in some cases a wide variation in the crop, unhealthy looking patches of smaller plants here and there proclaiming apparently a greater degree of toxicity than in the surrounding soil.

*Mustard*.—With this crop also the seedlings, after germinating well, early died out on the unlimed plots, with the exception of a few plants on one sub-plot, the disposition of these survivors suggesting that lime had carried over from a neighbouring limed plot.

The lime dressings alone, in the absence of other manuring, gave extremely poor crops, which were not much increased where cross-dressed with cowdung. The larger lime dressings appeared to be little, if any, more effective than the smallest one.

The crop only became of any importance where bone-meal was used along with lime, and in this case the superaddition of cowdung produced a very marked effect indeed.

The general appearance of the green-manured block during growth was not better than that of the non-green-manured. As the block has only been green-manured once, and as this forms the third crop taken since that time, two of which (oats and *jowar*) made much bigger crops on the green-manured block, this result is perhaps not very surprising, especially when one recalls the fact that *jowar* is a very exhausting crop.

The requirements of this soil for mustard would appear to be met by a small lime dressing and bone-meal and cowdung.

Without lime, the other manures were without effect. With lime, phosphate is the second necessary addition, and cowdung comes third if a really good crop is to result.

The above observations were generally confirmed by the final results as may be gathered from the appended table (Table VIII).

**TABLE VIII.**  
**BLOCK C.**  
*Jowar and Mustard, 1912-1913—2nd year of experiment.*

Cross dressings.	Non-green-manured block.				Green-manured block.			
	No lime.	Lime 20 mds. = (10 + 10).	Lime 30 mds.	Lime 60 mds.	No lime.	Lime 20 mds. = (10 + 10).	Lime 30 mds.	Lime 60 mds.
1	2	3	4	5	6	7	8	9
	Mds. sr.	Mds. sr.	Mds. sr.	Mds. sr.	Mds. sr.	Mds. sr.	Mds. sr.	Mds. sr.
Nil	J.= 0 0	J.= 63 30	J.= 84 40	J.= 127 20	J.= 0 0	J.= 48 20	J.= 115 0	J.= 150 0
	M.= 0 0	M.= 0 20	M.= 0 20	M.= 0 27½	M.= 0 0	M.= 0 10	M.= 0 7½	M.= 1 2½
Bone-meal 3 mds. per acre in 1st and 2nd year.	J.= 0 0	J.= 37 0	J.= 81 20	J.= 120 0	J.= 0 0	J.= 41 0	J.= 122 10	J.= 162 20
	M.= 0 0	M.= 6 0	M.= 4 30	M.= 3 37½	M.= 0 2½	M.= 3 32½	M.= 4 30	M.= 6 2½
Bone-meal 3 mds., cowdung 100 mds. in 1st and 2nd year.	J.= 0 0	J.= 66 0	J.= 87 20	J.= 163 20	J.= 0 0	J.= 73 20	J.= 220 0	J.= 209 20
	M.= 0 0	M.= 8 0	M.= 8 15	M.= 8 10	M.= 1 5*	M.= 6 12½	M.= 6 20	M.= 7 22½
Cowdung 100 mds. per acre in 1st and 2nd year.	J.= 0 0	J.= 91 0	J.= 129 20	J.= 221 20	J.= 0 0	J.= 80 0	J.= 167 0	J.= 191 0
	M.= 0 0	M.= 2 10	M.= 2 0	M.= 3 10	M.= 0 2½	M.= 0 35	M.= 0 32½	M.= 3 10

Yields are per acre—  
 J.= Green jowar.  
 M.= Mustard grain.

\* There appears to have been some small transference of lime into this sub-plot from the neighbouring 60 mds. lime plot.



*Financial aspect.*—A clearer and fairer idea of the behaviour of the two experimental blocks (green-manured and non-green-manured) under the differential manuring, will be obtained from a perusal of Table IX, wherein is set forth the total value of the cropping per acre for each sub-plot for the three crops oats, *jowar*, and mustard, together with the cost of manuring of each sub-plot, and the profit (P) or loss (L) resulting on the above crops.

For the immediate purposes of this table, the value of the straw of the oats and mustard crops has not been included.

Its inclusion would, of course, tend to send up the profits somewhat, or diminish the losses, as the case may be.

To the enquiring mind, the figures as they stand will readily reveal where the real value of the experiment lies.

In almost every sub-plot the value of the cropping (V) is greater on the green-manured block than on the corresponding sub-plot in the other block; this is especially noticeable on those plots receiving the heavier lime dressings of 30 and 60 maunds per acre, respectively, in which cases the average value of the cropping is almost exactly 33 per cent. greater than on the corresponding plots in the non-green-manured block.

Even though the value of the *aus* paddy crop which was grown on the non-green-manured block, while the other was under cowpeas for green-manure, be reckoned to its credit, the position remains much the same. In this case the average value, per sub-plot, of the cropping on the 30 and 60 maunds limed areas of the green-manured block, is some 20 per cent. greater than that of the corresponding sub-plots of the other block, while the average value of corresponding sub-plots of both blocks receiving only 20 maunds lime per acre is almost identical.

This is a very strong argument in favour of the practice of green-manuring where lime applications which are at all heavy are being used.

The figures show the very great value of lime on these soils for mixed cropping, but they prove a good deal more than that; they prove that not only is it advantageous to green-manure when liming, but also that if the best results are to follow, other manuring must not be neglected, indeed that it will pay to treat the land liberally in other directions.

Thus, with lime costing us Re. 1-12-0 per maund on the Farm, the table shows that even where 60 maunds lime was applied along with bone-meal and cowdung (the total cost of the manuring per acre for the two years amounting to the very high sum of Rs. 139-14-0), the two years' cropping has resulted in a small profit of Rs. 11 on the green-manured block. Again 30 maunds lime on the green-manured block, used with cowdung or with bones plus cowdung, has returned within 2 years, with the cropping given, a profit of some 60 per cent. on outlay in either case.

TABLE IX.

BLOCK C.

Cross dressings,	Non-green-manured blocks.				Green-manured blocks.			
	No lime.	Lime 20 maunds = (10 + 10).	Lime 30 maunds.	Lime 60 maunds.	No lime.	Lime 20 maunds = (10 + 10).	Lime 30 maunds.	Lime 60 maunds.
1	2	3	4	5	6	7	8	9
	Rs. a.	Rs. a.	Rs. a.	Rs. a.	Rs. a.	Rs. a.	Rs. a.	Rs. a.
Nil ...	V.= 0 0	V.= 39 11	V.= 59 14	V.= 65 6	V.= 0 0	V.= 39 9	V.= 70 11	V.= 80 6
	C.= 0 0	C.= 34 6	C.= 51 9	C.= 103 2	C.= 0 0	C.= 34 6	C.= 51 9	C.= 103 2
		P.= 5 5	P.= 8 5	L.= 37 12		P.= 5 3	P.= 19 2	L.= 29 12
Bone-meal 3 maunds per acre in 1st and 2nd year.	V.= 0 0	V.= 58 0	V.= 77 7	V.= 81 0	V.= 0 5	V.= 56 14	V.= 103 6	V.= 107 5
	C.= 0 0	C.= 52 6	C.= 69 9	C.= 121 2	C.= 18 0	C.= 52 6	C.= 69 9	C.= 121 2
		P.= 5 10	P.= 7 14	L.= 40 2	L.= 17 11	P.= 4 8	P.= 33 13	L.= 13 13
Bone-meal 3 maunds, cowdung 100 maunds in 1st and 2nd year.	V.= 6 0	V.= 82 8	V.= 102 16	V.= 117 14	V.= 5 5	V.= 97 2	V.= 142 14	V.= 151 2
	C.= 36 13	C.= 71 2	C.= 88 5	C.= 139 14	C.= 26 12	C.= 71 2	C.= 88 5	C.= 139 14
	L.= 30 19	P.= 11 6	P.= 14 9	L.= 22 0	L.= 31 7	P.= 26 0	P.= 54 9	P.= 11 4
Cowdung 100 maunds per acre in 1st and 2nd year.	V.= 3 6	V.= 66 7	V.= 89 5	V.= 109 4	V.= 9 5	V.= 74 4	V.= 112 0	V.= 134 15
	C.= 18 12	C.= 53 2	C.= 70 7	C.= 121 14	C.= 18 12	C.= 53 2	C.= 70 5	C.= 121 14
	L.= 15 6	P.= 13 5	P.= 19 0	L.= 13 10	L.= 9 7	P.= 21 2	P.= 41 11	P.= 11 1

V. = Value of grain of oats and mustard crop + value of green jowar crop.  
 C. = Cost of manuring per acre for the different plots for the first two years of the experiment.  
 All figures are \* per acre.

P. = Profit on 3 years' working.  
 L. = Loss " " "

*Summary.*—On the results of the first two years of the experiment the following tentative conclusions are put forward for mixed cropping on poor sour upland soils in Assam :—

- (1) That it will pay to use lime.
- (2) That it may be applied with profit up to initial dressings of 30 maunds per acre, especially if used in conjunction with green-manuring and the application of cowdung and phosphates.
- (3) That when using lime at all, green-manuring is advisable but becomes absolutely essential when applying anything like a large dressing.
- (4) That it will pay to lose an *aus* paddy crop occasionally in order to get in a full green crop.
- (5) Certain crops respond better to heavier dressings of lime than others, and demand more of it.
- (6) The first demand of the soil is for lime and organic matter containing nitrogen.
- (7) In the absence of lime and organic matter, other added manures may either fail altogether, or fail to exert their full value.

The experiment cannot yet, in the nature of the scheme, pronounce any verdict on the relative value of a single larger dose *versus* periodical smaller lime applications, but it would appear that anything larger than an initial dressing of 30 maunds is not advisable in any case.

*Wood ashes experiment.*—This was continued during the year, the annual dressings of wood ashes and cowdung being applied as usual.

The cropping was *jowar* and oats.

*Jowar* germinated fairly well all over the plots, lived a sorry life for some three weeks, and died out all over the block.

Evidently although wood ashes has destroyed the toxicity of this soil to oats to some extent, in the quantities applied by us to date it is not sufficiently effective to produce any sort of a crop of *jowar*, even where used with cowdung.

*Jowar* is particularly sensitive to soil toxins, and it would probably require enormously heavy dressings of wood ashes on our soil to produce a crop.

The oats crop in the cold weather germinated all over the plots.

The seedlings died out very early on the plot receiving no ashes, but struggled for a few weeks longer where the small dressings of 5 and 10 maunds were used.

In the result, small crops of oats were harvested from the 15 and 20 maunds ashes plots, the crop from the latter amounting to some  $3\frac{1}{2}$  maunds per acre, a very small yield but still a crop, and a much better crop than the same plot yielded 12 months before.

*Block K—Experiment.*—This was new field work laid down in the year under review.

It is a comprehensive experiment designed to ascertain if possible to what particular function of lime its observed early remarkably beneficial action on cropping may be due.

Lime might conceivably benefit cropping in a number of ways, *i.e.*, by supplying plant food, by improving the texture and the general biological conditions, or by liberating other plant foods from the soil reserves, etc., but though some of these desirable effects would appear to follow the application of lime very quickly, the results of this experiment go to prove most convincingly that its early beneficial action on cropping is undoubtedly primarily due to its power of neutralising and putting out of court the soil acids (some of which are highly toxic), thus leading to an immediate improvement in the soil's bio-chemical factor. Clearly the correction of acidity forms the very corner stone of any attempt to establish better general soil conditions, for most cultivated crops at any rate, and a knowledge as to the presence or absence of soil acidity becomes of fundamental importance in framing manurial schemes. The experiment showed clearly that in the presence of acidity not only did certain manures, and combinations of manures, have no effect on crop production, but that they did very definite harm in some cases.

With previous liming, using the same manures, the whole position was reversed, resulting in increase of crop.

It is hoped to publish separately, shortly, an account, with the whole of the most interesting results, of this experiment.

During the year under report an experiment was laid down on about 2 acres of the newly acquired area to test the action of different dressings of powdered limestone on this soil. The experiment is divided into two blocks, one of which will be cultivated by the ordinary country implements and the other by an English plough which turns up the soil to a depth of about 9 inches.

12. A small quantity of Manchurian soy-beans obtained from Chittagong was sown on both limed (lime applied 2 years previously) and unlimed areas. Soy-beans. Date of sowing was the middle of June, and of harvesting the beginning of December. The area of the limed plot was 0.17 acre and that of the non-limed plot 0.11 acre.

The following results were obtained :—

	Per plot grain.		Per acre grain.	
	Mds.	srs.	Mds.	srs.
Limed area	3	3	18	4
Non-limed area	0	17½	4	1

13. The following varieties were tried on small plots in the Kitchen garden area. The seed was obtained from the Upper Shillong Farm :—

Potatoes.

King of Potatoes	...	...	...	·10 acre.
Magnum Bonum	...	...	...	·07 "
Khasi Nainital	...	...	...	·05 "

The result was as follows :—

	Per plot.		Per acre.	
	Mds.	srs.	Mds.	srs.
King of Potatoes	9	9	92	10
Magnum Bonum	5	26	80	29
Khasi Nainital	2	25	52	20

14. This crop has now been grown for five years. During the year under report the crop was planted on  $\frac{1}{4}$  acre limed land, and also on about  $\frac{2}{3}$  acre of unlimed land in Block D. The crop on the limed area was unmanured, while 150 maunds of cowdung per acre was applied to the non-limed area.

The outturn from the limed area was 4 maunds of nuts or 16 maunds per acre, and from the unlimed area 8 maunds 14 seers or about  $12\frac{1}{2}$  maunds per acre.

The yield is very much less than last year owing to the destruction of a portion of the crop by rats.

15. This crop was tried for the first time at Jorhat on about  $\frac{1}{2}$  acre of land in the Kitchen garden area. The crop was sown on November 20th and grew well but was heavily laid by a storm before it was ripe. The crop was harvested at the beginning of March. The yield was  $2\frac{1}{2}$  maunds, equal to  $12\frac{1}{2}$  maunds per acre. The yield would probably have been at least 50 per cent. greater had the crop not been laid, resulting in a large proportion of light grain.

A small area of non-limed land was also sown, but the crop was a complete failure. This result is similar to that invariably obtained with oats on this soil.

16. *Aus* paddy was sown on Block E after the removal of the ratoon sugarcane. This was followed by *natikalai* in the cold weather.

Other crops.

Cowpeas for green-manure was sown over the whole experimental area in Block D, in preparation for sugarcane.

Dhaincha and sunn hemp were grown for trial on small areas of limed land in case it should be necessary to introduce them as green-manure crops at any time. They both grew very well, but the sunn was attacked by caterpillars.

17. The Mozafferpur lichi trees blossomed and set a large quantity of fruit, but high winds destroyed most of it.

Fruit.

Propagation by layering was tried successfully, and the "layers" was distributed to several people in the neighbourhood, the total price realized being Rs. 14.

Ceylon pineapples still continue to do much better than the Barbadoes and Spanish varieties.

Guavas are growing fairly well, but the fruits are small.

The only custard apple tree on the farm produced a few very good fruits this year.

The mangoe trees are stunted and up to the present have borne no fruit.

18. The receipts amounted to Rs. 2,110 (chiefly by sale of sugar), of which Rs. 17 was outstanding at the close of the year. This does not include the value (Rs. 75) of 15,000 sugarcane cuttings distributed free and supplied for demonstration purposes.

Receipts and expenditure

The total expenditure, including Rs. 1,979 for establishment and Rs. 2,070 for capital charges, was Rs. 10,784.

19. This consists of a Farm Superintendent on Rs. 100—10—200, a Fieldman clerk on Rs. 25—1½—40 and a peon on Rs. 8. There are also two apprentices under two years' practical training on stipends of Rs. 10 in the first year and Rs. 12 in the second year. Srijut Bina Ram Das held the post of Farm Superintendent throughout the year. Srijut Devi Prasad Gohain was appointed Fieldman clerk from October 23rd on the resignation of his predecessor.

Establishment.

Two new apprentices were appointed during the year, one Bholanath Gogai from October 25th and the other Bhudhar Phukan from November 10th.

20. The Hon'ble the Chief Commissioner, accompanied by the Commissioner of the Assam Valley and the Deputy Commissioner, inspected the farm in August.

Inspection.

The Director of Land Records and Agriculture inspected the farm on two occasions. The Deputy Director visited Jorhat nine times, inspecting the farm several times on each occasion. Mr. A. A. Meggitt accompanied the Deputy Director on three occasions and spent a considerable time on the farm in February, March and April in connection with the sugarcane work.

Other visitors included Dr. J. W. Leather (Imperial Agricultural Chemist), Dr. Butler (Imperial Mycologist), Dr. Hope (Chief Scientific Officer, Tea Association), the Hon'ble Mr. Forbes and the Hon'ble Mr. Playfair.

15th September 1913.

A. G. BIRT,

*Deputy Director of Agriculture, Assam.*



Appendix—A Note by Mr. Meggitt on soil acidity and the use of lime.

*Further notes on soil acidity and the agricultural use of lime.*

Last year's report (year ending 30th June 1912) contained a general note on the occurrence of acidity in high-land soils, and some aspects of the usefulness of lime as a corrective.

The present note is an extension of the above, based largely on the experience acquired during some five years' work in the field and Laboratory on the liming problem.

*When liming is necessary.*—It is not easy to indicate clearly every case in which liming will prove beneficial.

There are certain signs, however, which point to its necessity for the best growth of most cultivated plants, *i.e.*, when the soil is sour either as a result of excessive leaching out of lime compounds in tracts of heavy rainfall, or from the presence of fertiliser residues or excessive amounts of organic matter, or from combinations of the above causes; when such plants are sorrel, rushes and sedges, certain coarse creeping grasses, etc., are relatively abundant; when clay soils become too sticky and cultivation and drainage are difficult; when the soil fails to respond adequately to manuring; in all such cases lime will prove helpful.

It will also prove useful in those cases where leguminous crops, as commonly used for green-manuring purposes, fail or do not make proper growth, except when heavily manured beforehand. One point must here be emphasized and that is that in such cases liming alone will generally prove insufficient. By rendering available the reserve food supply of the soil it may act favourably for a time, ultimately leading to a measure of soil exhaustion.

The great thing when liming is practised is to keep up the supply of humus by green-manuring and the use of organic manures, and it is fortunate that lime generally assists the growth of green crops very considerably.

At the same time the systematic supply of other manures must not be neglected. Of such manures some, notably phosphates, will, especially on red stiff soils, be considerably more effective after a preliminary liming.

*Time and manner of application.*—Early in the year, about February or March, is probably the best time to apply lime dressings, as by that time cold weather crops are off the ground and opportunity is given before the rains-crops are sown of thoroughly working the lime into the soil, and this course also allows time for the lime to sweeten the soil. Lime, in whatever form it may be used, should always be applied alone and usually some few weeks in advance of other manuring, otherwise losses may occur when using certain manures.

It should never be spread when the soil is in a very wet condition, particularly on clay soils. On very sticky clay soils attention to drainage should always precede liming.

The lime should be broadcasted evenly over the land and thoroughly worked into the surface soil as soon after as possible. It is necessary to emphasize this as otherwise the lime will not exert its full early effect, and undue local alkalinity may ensue due to uneven application, if the application is at all a large one. Further, if heavy rain follow, the lime may be washed off the surface into the drains. Our experiments have shown that added lime takes an appreciable time to enter into its various combinations in the soil, and until it becomes thus fixed it is subject to greater loss in drainage water. This loss of lime to the surface soil will be greater the heavier the dressing, unless special care be taken to incorporate it well soon after spreading. The thoroughness with which this can be done, and the depth to which the lime is thus incorporated with the soil, are amongst the factors to be taken into account in deciding what amount of lime to apply in any given case.

*Quantity of lime to be applied.*—This depends upon a number of considerations, and speaking generally it is safe to say that nothing less than actual experiment over a number of years for any particular kind of soil and cropping and climatic conditions can properly decide the matter.

There is probably no phase of agricultural practice upon which a greater diversity of opinion may be found in literature than in regard to the question of liming.

Customs which appear to be thoroughly justified by practical experience in one country and on a certain class of soil, may not give the same results on a similar class of soil in another country.

Practical experience then as a result of careful, well-planned schemes of experiment, is what is most to be desired.

Speaking generally, one finds a very general agreement that in very wet climates clay lands will benefit much as a rule from liming, while light sandy soils respond readily when sufficient organic matter is naturally present, or is added, for the lime to act upon.

As regards what quantity may be safely and profitably applied, such considerations as the re-action of the soil (*i.e.*, whether acid or not and the amount of acidity); the amount of organic matter present or which can be added by green-manuring, etc., the texture, whether heavy or light, the cropping to be followed, must all be taken into account.

The greater the acidity the more lime will be required to sweeten the soil, leading to those favourable biological conditions which are associated with maximum crop production in the case of most cultivated plants.

Since lime hastens the decomposition of organic matter, if it is applied, in absence of green-manuring or supplies or other organic manures, in too heavy doses to soils already deficient in humus, it may lead to excessive exhaustion in respect of this most valuable soil constituent.

It is generally agreed that clays can bear more lime than light sandy loams, on account of the extra amount stiff soils require to keep their texture right.

At Jorhat where the soil is light the heaviest dressing of lime (2 tons per acre) depressed the yield of early cropping where green-manuring and cowdung were not also used; on the other hand, where they were applied, even this heavy application of lime increased the yield, though far from profitably, over that given by the next smaller quantity, *viz.*, 1 ton per acre.

At Dacca where the soil is stiffer and contains much more clay, the above early adverse effect of the heaviest lime dressings was not apparent.

In regard to the influence of the cropping to be followed upon quantity of lime to apply, it is undoubtedly a fact, which our experiments have confirmed, that some crops are more tolerant to a certain measure of soil acidity than others, so that other conditions being suitable smaller applications will enable the former to yield well.

Formerly the custom in Europe was to use very heavy dressings at relatively long periods. Liming was overdone and fell into disuse, the latter being hastened by the advent of artificial fertilisers. There is to-day a distinct recrudescence of the practice of liming, and latterly small dressings at more frequent intervals have become customary. Obviously the quantity to be applied must depend upon the frequency of application, as well as on the purpose it is sought to accomplish.

In certain cases a fairly large initial dressing may be advantageous, but it would be well first to prove by actual test that the larger dressings actually give a profit over and above that yielded by smaller ones, before going to the expense of heavy applications.

Smaller dressings at more frequent intervals are more likely to prove economical in the long run than large doses at longer intervals, because lime does not exert its maximum effect over

very many years, and is one of the soil constituents that is most quickly removed in drainage water, in this way being lost to the surface soil; where its presence is most to be desired.

Our experiments show that the loss by drainage following the application of the larger doses of slaked lime is greater than in the cases of the smaller dressings.

For light soils almost certainly light dressings applied more frequently should be the rule.

Where the surface soil is very deep and deep cultivation is practised, the application at any one time may be proportionately increased.

Though our field experiments at Jorhat and Dacca are still too young to speak positively on the point, up to date they appear to favour the smaller and more frequent applications as being likely to prove the more economical in the long run. At any rate where large areas are to be treated, there is ample justification on all grounds for saying that, in the absence of direct experimental results to the contrary, the safest and sanest policy to pursue will prove to be to use moderate dressings, say up to 10 or 15 maunds per acre at first, though a repetition at no distant date may prove advantageous, since in many parts of the Assam Valley and Bengal such an amount of lime is quite insufficient to neutralise the acidity, and thus establish healthy soil conditions even in the first three inches of soil.

Indeed our work shows that very much larger applications would be necessary to establish even a very small working reserve of carbonate of lime in the surface soil.

On the light sandy loam at Jorhat, experience so far goes to show that about 30 maunds slaked lime is the maximum permissible initial dose per acre. Even this quantity only sweetened the surface soil to a depth of some 3 inches for a comparatively short period.

Eighteen months after the above application, the surface soil had become sour again, indicating that for general cropping more lime will soon be required.

While it is thus fairly clear that some 30 maunds is probably the maximum dressing permissible initially on this class of soil, it does not at all follow that it will prove in the end more economical than smaller doses repeated at intervals. Time alone can decide this point.

*Frequency of liming.*—This will depend largely on circumstances. Where a single initial heavy dressing has been given, its effects may persist for a number of years, say 6 to 10, and in

many cases a ton per acre applied once in 6 to 10 years would suffice.

But on arable land in heavy rainfall tracts it may well prove that subsequent applications will need to be more frequent if the soil is to be kept in the best condition.

In this connection it is well to recall that lime carbonate is one of the least permanent soil constituents. The average loss for England and Wales is estimated at some 500lbs. per acre per annum in drainage water.

It is true that the annual loss may be influenced by the choice of manures, *e.g.*, increasing where sulphate of ammonia is used, and diminishing with increased use of cowdung, and very probably where green manuring is regular.

Again on arable land it is greater than on pasture. In countries of heavy rainfall it is quite likely that the annual loss to the soil will exceed the figures given above.

Allowing the annual loss by drainage to be not greater than 500lbs. carbonate of lime per annum per acre, this would require an addition of good slaked lime (containing 70 per cent. pure lime) at the rate of 5 maunds per annum, or say 20 maunds every four years.

However, this figure may well represent the maximum requirements, since added lime is generally only mixed with a comparatively shallow soil layer, and practically the whole of the lime remains in the surface soil, except that washed out by solution.

In practice it is not even necessary that a soil should be admixed with lime to any very great depth, since it is within a foot or so of the surface that the feeding roots of most plants are to be found, and where, moreover, the beneficial soil re-actions take place.

If then there be maintained a small working reserve of carbonate of lime in the first foot or so of the soil, it will keep the soil healthy, and provide all that is necessary to meet changed conditions in time of drought, when the up-coming capillary water brings soil acids with it from below.

It may well prove then that even on heavy clay soils which admittedly require a higher percentage of carbonate of lime to keep them in condition than lighter soils do, that once the soil has been got into fair condition an application of 15 maunds of slaked lime once in 4 to 6 years may suffice to keep them in good tilth and fertility.

On lighter more sandy soils otherwise under similar conditions an amount of 8 to 10 maunds every 4 to 6 years may prove sufficient.

In the latter case, more especially, it will probably prove more advantageous to apply, say, 4 or 5 maunds every 3rd year than 8 to 10 maunds every 6th year.

The above figures are for slaked lime of good quality.

If ground limestone be used instead, then the quantities to be applied will be from one and a half times to twice as large, depending on the composition and fineness of the ground limestone.

*Form of lime to use.*—Experience does not yet provide the full answer to the question as to which form of lime is the best to use, *i.e.*, slaked lime or carbonate of lime, in all circumstances. Literature provides instances in favour of either as against the other.

A marked preference for burnt lime on stiff soils exists; this may or may not be due to the fact that burnt lime has always been readily obtainable, while limestone in a sufficiently fine state could not be bought.

More recently finely ground limestone has been experimented with largely in America with the very best results in practice.

For various reasons it is generally assumed that burnt lime must become converted into carbonate of lime very soon after it is mixed with the soil.

This may very well not be the case on acid soils at first, since added lime will immediately combine with the soil organic acids to form neutral salts.

This appears certainly to have been the case at Jorhat, where in searching for reasons for the remarkable early beneficial action of lime, I have not been able to detect by the most delicate tests any increase in the percentage of carbonate of lime in the surface soil from even the 60 maunds lime plots some 12 months after the application, while even only 3 months after spreading the lime, though there was a very slight accession of carbonate, it was not sufficient to account for more than one-fifth of the lime which had been added.

On the other hand, other tests showed that one of the very earliest actions of the lime was to combine with the objectionable soil organic acids to form insoluble lime compounds of a favourable character.

It may well prove then that for very sour soils, whether light or heavy, also for stiff clay soils for reasons which will presently appear, the use of slaked lime as a preliminary soil ameliorant may have a time advantage over ground limestone, as it would overcome sourness more quickly, and on stiff soils it acts more rapidly in improving the texture.

Further, the caustic action of burnt lime as a fungicide is not exercised by the milder carbonate.

In certain cases there thus appears to be strong evidence favouring the use of burnt or caustic lime in correcting bad soil conditions, but once the soil has been brought into fair condition, there are the very best reasons for saying that in order to keep up this favourable condition, for subsequent applications a finely ground limestone will have all the advantages, and none of the disadvantages which sometimes attend the use of burnt lime.

I believe that the only advantage of using burnt lime in certain cases rather than limestone lies chiefly in the fact that certain ends may be achieved in less time.

Some of the desirable effects which it is sought to bring about in a soil by the use of lime are as follows:—The correction of sourness, the improvement of texture, the improvement of biological processes, and the liberation of available plant foods from insoluble reserves.

As regards the correction of sourness, finely ground limestone is quite effective, though somewhat slower in action than burnt lime.

Improvement in the texture of stiff soils by liming is due to flocculation of the fine clay particles. Bicarbonate of lime has this power, and bicarbonate is readily formed in the soil after the use of limestone, but flocculation cannot take place until the carbonate of lime contained in the limestone has been converted into the soluble bicarbonate. Thus it may take a longer period of time to effect a marked change in a clay soil as regards texture when using limestone, than would be necessary if burnt lime were used, because the burnt or hot lime as such itself has a marked flocculating action which may be exercised appreciably before it becomes carbonated. Once it has been carbonated any further flocculating action depends, as in the case of limestone, upon its conversion into the soluble bicarbonate in the soil.

With regard to improvements in soil biological processes, Warington found that lime water was much too alkaline for nitrifying organisms, and more recent work clearly shows that the

use of caustic lime does at first have an inhibitory effect on nitrification; very possibly the same may be true of other biological soil processes. This early inhibitory action of the lime, however, is not of long duration, and is followed by increased activity of the nitrifying organisms.

The use of the milder carbonate of lime in the form of ground limestone more favourably affects nitrification. Carbonate of lime again is capable of liberating available plant foods, *e.g.*, potash from the insoluble reserves. At Rothamsted, chalk applied to the permanent grass plots both increased the crops and materially changed the character of the herbage, these results being attributed to liberation of potash from the stores in the soil.

From the above it will be seen that all these beneficial soil processes may be ensured by the use of a finely powdered limestone.

At Jorhat a preliminary experiment in the use of ground limestone has shown the same favourable action as has been obtained by using slaked lime on our ordinary agricultural cropping.

It is slower, perceptibly so, in action but it is sure and safe, and except perhaps in those cases above noted, *i.e.*, when the soil is very sour or on clay soils where texture is bad and drainage difficult, for which cases burnt lime may suitably be used for the early applications, except in these cases the use of a finely ground limestone may be strongly recommended.

Even in the case of exceptionally bad soils where burnt lime is used at first to ensure an early improvement (and more recent work at Jorhat has proved the vital necessity of first getting rid of acidity as a preliminary to further treatment) for future recurring dressings after the land has been got into fair condition, limestone will form the most suitable addition.

All the benefits which follow the case of caustic lime will be obtained, but in somewhat greater time.

Again limestone can be safely mixed with certain manures without danger of loss, which is not true of caustic lime though the separate addition of lime in any form is to be advocated.

Limestone has a milder action in decomposing organic matter in the soil, the amount of which is in many cases already all too small. Even this consideration must not be made an excuse for not green-manuring regularly, if the most is to be made of the soil's resources and of other manures applied.



It is further much easier and more pleasant to apply than slaked lime, and the consequences of the use of an accidental overdose are negligible compared with those which may follow the use of too much of the latter.

It is necessary to point out that even with high quality limestone containing some 90 per cent. carbonate of lime, to supply a given quantity of pure lime will need about one and a half times as much limestone as if one were using a good slaked lime containing some 70 per cent. pure lime.

Where immediate results are required, the finer the limestone is ground the quicker it will act, and less of it will be required to serve an immediate end than if one used a coarse product.

If ground to all pass a sieve of 50 or 60 meshes to the linear inch, it will act very quickly indeed.

In such cases therefore where limestone is being used for early applications, rather than slaked lime, it should preferably all pass a 60 mesh sieve.

Once better soil conditions have been established however, and to prevent a relapse of the soil into sourness, for future additions a coarser and therefore probably cheaper product would answer well, and for this purpose, provided all the finest material produced during the grinding be included, I am of opinion that it will do very well if it will all pass a 30 mesh sieve; this would mean that a very considerable proportion would pass a very much finer sieve.

The present position in regard to the supply of ground limestone on the Indian market is in a very unsatisfactory state indeed.

There is springing up a demand for this commodity which even to-day can only be partially met, and the demand seems likely to increase rapidly.

In a province where its use would appear to be fraught with such great possibilities, *e.g.*, Assam, it can hardly be obtained and then only at a comparatively excessive cost.

In America (Illinois) ground limestone can be bought delivered 100 miles by rail from the quarry at 1 dollar 20 cents or Rs. 4 approximate per ton. Even where it must be railed much longer distances the equivalent of Rs. 15 per ton delivered is considered so excessive as to make its use prohibitive.

It is stated that the grinding can be done for 25 cents a ton where a large plant with powerful machinery is used and where fuel is cheap, as near the coal mining districts.

This is probably not very fine grinding, but even in this case one cannot conceive that the cost of grinding can exceed a very few rupees per ton.

Co-operation amongst large users should succeed in reducing the present excessive cost to a reasonable figure.

What will happen in practice will almost certainly be that all other considerations will be subordinated to that of relative cost, and this is a point which it would be well for the trade to recognise.

*Early chemical and physical effects of lime on acid soils.*—Coincident with improved cropping, certain very definite chemical and physical effects have been observed in our experiments at Jorhat and Dacca.

The most obvious has been the partial or complete neutralisation of acidity (according to the amount of lime used), a change which is almost entirely confined to the cultivated surface layer. This has a very evident important bearing on the subject of liming. A temporary but quickly fugitive very slight increase in the per cent. of carbonate of lime followed the application of the large initial dressings.

A definite combination of lime with organic compounds of an acid nature, to form the so-called calcium humates, which constitute the active organic matter of the soil, was early demonstrable. A decrease in the stiffness of the straw on the more heavily limed plots indicates further and more obscure combinations of lime with inorganic compounds of an acid character. This is being investigated.

Improvement in physical texture is clearly marked on the heavy soil at Dacca; it is less sticky and easier to work. At Jorhat the greatest improvement noticeable to date is in the physical condition of the sub-soil which in the natural condition shows a tendency of pan.

The increased efficiency of insoluble phosphates when used along with lime as measured by solubility in weak acid solvents, is very clearly marked. It is also reflected in the crop yields.

It seems perfectly obvious that before there can be formed any reserve of carbonate of lime in the soil—and a small reserve is desirable in tracts of permanently acidifying conditions—the soil acids must first be neutralised, and in addition other possible soil combinations must be satisfied, and it appears very likely that over many parts of the Assam Valley it will require more lime to effect this than may be commonly supposed by those who have no positive experimental evidence on the point.

While sandy soils can get along well with as little as 0.1 per cent. of carbonate of lime, it requires more than this to keep stiffer soil in good condition.

In this connection and in reference to the ascertained presence of a definitely toxic substance in the Jorhat soil, recent work by the American Bureau of soils has rendered it quite clear that certain of the decomposition products formed in soils during the breaking down of organic matter may be beneficial to the plant, others definitely harmful, and upon what sort of soil treatment is given depends largely whether toxic substances shall accumulate to such an extent as to exert a definitely poisonous effect on crops.

Among the causes contributing to the presence of a deleterious bio-chemical soil factor with resulting accumulation of toxic soil compounds are :—

- (1) Absence of a sufficiency of carbonate of lime.
- (2) Insufficient drainage.
- (3) Poor cultivation.

It is certainly possible by paying attention to the above points to ensure that the soil bio-chemical factor shall be favourable; the result being that the various soil processes will tend to the formation of such compounds as are not only not toxic but are positively beneficial, contributing directly to the food supply and general welfare of the plant.

To get the maximum value therefore out of the soil and from added manures, it is necessary to get and keep this bio-chemical factor right, and this is quite incompatible with the presence of acidity and absence of carbonate of lime, so far as most of the cultivated crops are concerned.

The periodical supply of lime therefore, combined with proper attention to drainage and cultivation, would appear to form the very corner stone of any attempt at permanent improvement of adverse soil conditions.

The scientific work which is now being done in this field of soil chemistry is, amongst other things, supplying the reasons for a practice which has long been in vogue amongst farmers almost the world over, *viz.*, the use of lime in those cases where applications of manure fail to correspondingly increase the crop. A sound application of the *raison d'être* of this custom would be a good thing in certain parts of India too.

*Relation between heavy rainfall and the effect of soil acidity on cropping.*—Particularly at Jorhat, less markedly at Dacca, has it been noticeable that lime exercises a very much greater

effect on cold weather cropping as compared with many rain crops.

This difference is probably not unconnected with the very divergent soil conditions which obtain during the two seasons.

In the rains the amount of soil moisture is high, leading to a lower concentration of soil acidity, and also down percolation is constant. In the cold weather when percolation is small or nil, the lower soil moisture content coupled with the rise of capillary water from below would tend to increase the concentration of acidity in the surface soil.

This may partly explain why certain crops, *e.g.*, *matikalai*, grown in the rains generally make much more vegetative growth than when taken as a cold weather crop, and also why, with the exception of *jowar* which responds in a most extraordinary way to liming in the rains, other rains crops, *e.g.*, groundnut, cow-peas, etc., though benefiting very materially from lime, do not show that vast superiority which is so manifest on cold weather cropping, *e.g.*, oats, mustard, barley, etc.

For rain crops it will be, I take it, during seasons of short rainfall or during dry spells within individual seasons, that lime will have its greatest effect. Crops like soy-beans which continue their growing period into the dry weather months, have also shown at Jorhat to derive the greatest benefit from lime applications.

While we have thus shown that certain legumes, *e.g.*, soy-beans, groundnut, etc., will grow in the absence of lime during the rains and even develop root nodules, the improvement in their growth and colour which is manifest after the use of lime suggests that these crops in its absence possesses a relatively smaller power to fix atmospheric nitrogen.

They may be forced, in the absence of lime, to more or less luxuriant growth by the application of good dressings of cow-dung, cake, etc., but in such cases they must undoubtedly take a very large part of their nitrogen from the manure supplied, rather than from the air, and though far from deprecating the use of a certain amount of manure to help along the growth of a green-manure crop in some cases, it would appear economical to use a preliminary lime dressing in addition, which will not only assist the green crop but also help to decompose it later on and turn its decomposition into the best channels.

*Possible injury by injudicious liming.*—Reference has already been made to the care which is necessary in using lime on poor light soils deficient in organic matter, and to the urgent necessity of combining green-manuring with the use of lime in such cases.

It is necessary also to point out that even clay soils may ultimately become solid and compact rather than friable and easy working, if applications of lime be too frequent and in excessive quantities. This is due to a cementing action of carbonate of lime similar to the change which takes place in mortar.

Similar injury may result upon the excessive use of burnt lime on a clay soil in too wet a condition. The necessity for attention to drainage in such cases is to be reiterated.

It is to be observed also that in some soils a pan exists between surface and sub-soil, which alike impedes the range of plant roots and movement of water from below in dry periods. Variation in the depth of cultivation from time to time, combined with the moderate use of lime, will generally prevent the formation of these pans. Once such a pan is already formed however it may even be aggravated by too heavy liming, forming what is known as lime pan.

In case heavy liming is for exceptional reasons indicated as desirable in any particular case, it is well to see that there is no hard pan present.

Particularly in its destructive action on organic matter lies the danger of the too frequent use of lime. It is to the abuse, rather than the proper use, of lime that we owe the existence of such proverbs as this—

“Lime and lime without manure  
Makes both farm and farmer poor.”

As Storer remarks “when the use of lime first became general in Europe, the farmers were prone to believe that it could be used as a substitute for stable manure. Hence a tendency to abuse in using it. No doubt many a field has been reduced to the verge of sterility by applying lime until the entire store of available nitrogen, phosphoric acid and potash has been used up. All the evidence teaches that lime is no substitute for manure; it is a mere addition or reinforcement which may occasionally be employed with advantage.”

Again Storer has it that “excepting for clays and in some cases where it may do good as a means of correcting sourness, lime is not a thing to apply to really poor land. Generally speaking, it can hardly be profitable unless the soil is already fairly well charged with the constituents of plant food. Its function is to alter and improve matters that are already in the soil, and to make them more easily available for crops, as well as to bring the soil into such condition that it can enable added fertilisers to be put to better use than they could have been without the liming. It is an adjunct to be used occasionally, but no proper substitute for manure.

In other words occasional liming with systematic attention to manuring should go hand in hand together.

In conclusion, no better advice can be given to those who wish to really learn more about the subject than that they should experiment for themselves—preferably under scientific guidance and control—but experiment and be guided by results.

A. A. MEGGITT,

*Agricultural Chemist, Bengal.*

**R E P O R T**  
**ON THE**  
**UPPER SHILLONG AGRICULTURAL EXPERIMENT**  
**STATION**

FOR THE YEAR ENDING

JUNE 30TH, 1913.

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The Upper Shillong Agricultural Station was established in 1897-1898. It is situated on the Cherrapunjee road,  $5\frac{1}{2}$  miles from the town of Shillong, and occupies the site of the old "Model Farm" which ceased to exist in 1879. The elevation of the station is 5,900 feet, *i.e.*, about 900 feet higher than Shillong town. A large area of pine forest was annexed to the station in 1905. The total area of the farm, inclusive of forest, is 336.67 acres. Most of the cultivated land lies on the slope of a long narrow valley, the bottom of which consists for the most part of marshy land covered with a thick growth of wild grass. A considerable area of land has been reclaimed by deepening and straightening the stream which drains the valley and cutting lateral nullahs to connect with it. This work is being continued and extended, but the results of the work already done are very apparent. Soft boggy ground on which previously it was unsafe to work has been converted into firm pasture land, and at the same time the herbage shows a marked change for the better.

The soil of the greater part of the station is a coarse reddish loam of very loose texture which can be worked with the greatest ease. The sub-soil is of a more pronounced reddish colour and of great depth. In a small portion of the station the soil is black owing, it is believed, to the existence of some mineral compound. The soils have not been analysed. In point of quality, they are extremely poor, and very little can be grown on them without the help of manure. At the bottom of the valley a different type of soil is found, namely, clay or clayey loam, extremely rich in organic matter. Having been under a thick growth of grass for many years, the upper portion of this soil is a matted mass of half decayed grass roots.

Besides the natural poverty of the soil, the greater portion of the station suffers from the disadvantages of an exposed situation. It is colder and more windy than Shillong: frosts are of very common occurrence and are more severe than the town. During the winter the growth of vegetation is entirely suspended.

2. The main objects for which the station was established were the introduction of superior varieties of potatoes—which are the most important crop grown on the plateau of the Khasi Hills—the breeding of improved strains of cattle suitable for this tract, and the cultivation of fodder crops and making of ensilage for use in winter when green fodder is short. These objects are still kept in view, and in addition sheep-breeding experiments with the object of improving the local breed have since been commenced.

3. The following table gives the rainfall during the year under report:—

Weather.					Inches.
1912—					
July	...	...	...	...	18·27
August	...	...	...	...	10·98
September	...	...	...	...	10·45
October	...	...	...	...	10·98
November	...	...	...	...	5·29
December	...	...	...	...	0·10
1913—					
January	...	...	...	...	0·06
February	...	...	...	...	2·06
March	...	...	...	...	1·84
April	...	...	...	...	2·51
May	...	...	...	...	11·67
June	...	...	...	...	25·81
					100·02
					100·02

Although the total rainfall was well above the average (90·8 inches being the average for the last 14 years), it was deficient in March and April and specially so in the latter month. This was extremely detrimental to the growth of the potato crop, which, on the cultivators' holdings in the neighbourhood, began to die off in April, with the result that many people scarcely got back more than their seed.



The crop on the farm suffered to some extent, the yields being below the average, but nevertheless produced sufficient to shew a good margin of profit. This was undoubtedly due to a great extent to the superior methods of cultivation followed on the farm where the land is ploughed up about 8 inches deep with an English plough in the autumn and allowed to weather throughout the winter; although the fact that our crop was planted rather later than that of the cultivators was also in our favour, as the plants being younger were able to benefit from the rain in May.

For the cultivator of only one acre of potatoes in these hills, I am convinced that the purchase of an English plough would be advisable, provided his land is not too hilly: as in an average season the increased yield of potatoes, due to the better conservation of moisture in spring made possible by deep cultivation, would more than pay the cost of the implement. The price of the plough which we recommend is about Rs. 50 delivered at Shillong. There is a smaller plough costing less than this, but it is not so efficient. Any cultivators wishing to purchase these ploughs should apply to the Farm Superintendent, Upper Shillong. For very small holders I would suggest that several club together and purchase a plough. Failing this there would be a good opening for an enterprising man owning two pairs of good bullocks to purchase a plough, and take up contracts for ploughing at so much an acre. The larger plough will do about 2 acres in three days. Anyone wishing to take this up, can be taught to use the plough at the Government Farm, on application to the Farm Superintendent.

Construction work. 4. During the year the following buildings were constructed :—

	Rs.
Farm Superintendent's quarters ... ..	1,160
Fieldmen and clerk's quarters ... ..	997
Inspection bungalow (including servant's quarters and stable):	1,336

The cost shewn is exclusive of timber which was supplied from the farm forest.

The road from the Cherra main road to the farm godown was metalled at a cost of Rs. 300.

A cylindrical pit silo 14' x 11' with a thatched roof was sunk at a cost of Rs. 34.

Summary of work. 5. The work done during the year included :—

Reclamation.

Potato experiments.

Potato growing for seed.

Rice experiments.

Trials of various new fodder crops.

Other crops.

Selection experiments.

Growing indigenous fodder crops on a large scale for silage and hay.

Cattle breeding.

Sheep breeding.

6. It was mentioned in last year's report that an attempt had been made to bring a portion of the peaty soil in the valley under cultivation by a system of open drains. This was not very successful owing to the drains being too far apart. Any extension of this system was, however, undesirable since, if a sufficient number of open drains were employed, the land would be cut up into sections too small for bullock-power cultivation. Consequently this year a system of feeder drains was employed, the drains being partially filled up with brush-wood and finally covered in with earth. This method is working very well; a good portion of the marshy land in the upper part of the valley has been made dry enough for cultural operations, and, now that cultivation has been commenced, the condition of the soil should improve from year to year. A portion in the lower part of the cultivated area, however, is still insufficiently drained, and this will be attended to next cold weather.

Altogether 11 acres of land were reclaimed; nine acres were sown with *Raishan* and two acres with rice. The rice land was laid out in  $\frac{1}{10}$  acre plots.

In addition to the above, an area of about two acres of land carrying coarse jungle grass was ploughed up and cultivated during the cold weather, and, after levelling, was allowed to go down to grass again. This was with a view to improve the natural herbage, as it had been observed that one or two small patches of land which had gone out of cultivation were carrying finer grasses than the coarse herbage which forms the natural pasture on the uncultivated area. The grazing on the area so treated is already much improved, so it is proposed to extend the operations next year to other similar areas.

Potato experiments. 7. These included :—

- (a) Variety tests.
- (b) Summer grown *versus* winter grown seed.
- (c) Whole *versus* cut sets.
- (d) Manuring experiment.
- (e) Trial of old sets.

8. The following varieties were compared on duplicate plots,  
Variety tests. each  $\frac{1}{10}$ th acre in area :—

Khasi Round, obtained locally in	...	...	1900
Khasi Nainital ditto	...	...	1908
King Edward VII, from England	...	...	1906
Sutton's Magnum Bonum, ditto	...	...	1908
Winsor Castle, ditto	...	...	1909
British Queen, ditto	...	...	1909
Up-to-Date, ditto	...	...	1909
King of Potatoes, ditto	...	...	1912
Magnum Bonum, ditto	...	...	1912
Windsor Castle, ditto	...	...	1912
British Queen, ditto	...	...	1912
Gladiator, ditto	...	...	1912
Flour Ball, ditto	...	...	1912
Harbinger, ditto	...	...	1912
Imperator, ditto	...	...	1912
Belle de Juliet, ditto	...	...	1912
White City, ditto	...	...	1912
Californian, from California	...	...	1912

All the varieties were planted in March and harvested in July. Sets were from the previous winter crop. The land was given a dressing of 300 maunds of cowdung and 10 maunds of rape cake per acre, and the crop was sprayed with 240 gallons of Bordeaux mixture per acre in two equal doses,

The following statement shows the average yield per acre on duplicate plots for the last six years.

Variety.	1913.	1912.	1911.	1910.	1909.	1908.	Average of last two years.	Average of six years.
1	2	3	4	5	6	7	8	9
	Mds. srs.	Mds. srs.	Mds. srs.	Mds. srs.	Mds. srs.	Mds. srs.	Mds. srs.	Mds. srs.
1. King of Potatoes ... ..	186 20	234 0	201 0	131 20	95 30	319 0	210 10	184 25
2. Magnum Bonum (1908) ... ..	165 20	232 0	160 35	132 20	87 30	277 0	108 30	175 37
3. King Edward VII ... ..	133 20	128 20	163 13	78 20	90 15	269 0	131 0	143 34
4. Khasi Nainital ... ..	174 10	166 20	157 30	119 0	111 30	293 0	170 15	170 8
5. Khasi Round ... ..	123 0	111 20	135 2	95 25	102 25	255 0	117 10	137 5
6. Windsor Castle ... ..	158 20	205 0	181 15	63 15	...	...	181 20	...
7. British Queen ... ..	162 30	181 20	189 3	92 30	...	...	167 5	...
8. Up-to-Date ... ..	186 20	178 0	153 0	90 0	...	...	182 10	...
9. Magnum Bonum (1912) ... ..	156 0	224 0	...	...	...	...	190 0	...
10. Windsor Castle (1912) ... ..	129 0	106 0	...	...	...	...	163 20	...
11. British Queen (1912) ... ..	142 10	72 20	...	...	...	...	107 15	...
12. Gladiator (1912) ... ..	127 10	93 20	...	...	...	...	110 15	...
13. Flour Ball (1912) ... ..	160 30	173 0	...	...	...	...	166 35	...
14. Harbinger (1912) ... ..	108 30	126 0	...	...	...	...	117 15	...
15. Emperor (1912) ... ..	167 20	211 0	...	...	...	...	189 10	...
16. Belle de Juliet (1912) ... ..	63 20	81 20	...	...	...	...	72 20	...
17. White City (1912) ... ..	82 0	80 20	...	...	...	...	81 10	...
18. Californian ... ..	9 25	...	...	...	...	...	...	...

Of the older varieties King of Potatoes has again given the heaviest yield, while Khasi Nainital and Magnum Bonum are also good. Khasi Nainital is really the old Magnum Bonum variety which was introduced into the Khasi Hills from Nainital many years ago. This variety is still very largely grown by cultivators, but has become susceptible to disease. On an average of 6 years' results King of Potatoes is first as regards yield, followed by Magnum Bonum and Khasi Nainital.

Of the varieties more recently imported, Up-to-Date and Imperator are the most promising, Up-to-Date having doubled its yield since it was first imported.

As in former years, 50 tubers of each variety were selected at random, cut open and examined for signs of disease. The following table gives the results of the last five years:—

Variety.	Number of diseased tubers.				
	1909.	1910.	1911.	1912.	1913.
King of Potatoes*	10	12	Nil	Nil	Nil
Magnum Bonum (1908)	...	6	4	2	4
King Edward VII	Nil	18	8	4	6
Khasi Nainital	10	43	16	8	4
Khasi Round	Nil	4	8	6	10
Windsor Castle	...	...	...	4	3
British Queen	Nil	12	Nil	6	4
Up-to-Date	...	4	32	16	4
Magnum Bonum (1912)	...	...	...	6	6
Windsor Castle (1912)	...	...	...	4	3
British Queen (1912)	...	...	...	4	4
Gladiator (1912)	...	...	...	8	4
Flour Ball (1912)	...	...	...	6	3
Harbinger (1912)	...	...	...	2	8
Imperator (1912)	...	...	...	22	3
Belle de Juliet (1912)	...	...	...	6	Nil
White City (1912)	...	...	...	10	9
California	...	...	...	...	3

\* Figures for 1909-11 are for the old stock of King of Potatoes imported in 1906, while those for 1912-13 are for the new stock imported in 1912.

These figures must not be regarded as an absolute test of the amount of disease in the crop, but taken over a series of years they indicate to some extent the comparative disease-resisting power of the several varieties. King of Potatoes stands easily first as regards freedom from disease, in addition to being the heaviest cropper. Khasi Nainital, which according to this test was diseased to the extent of 96 per cent. in 1910, has gradually improved, until now only 8 per cent. are returned as diseased. It is only fair to state, however, that this variety returned more completely rotten potatoes at harvest time than any of the other varieties.

9. These experiments have been carried out for several years with the result that it has been definitely proved that winter "seed" (*i.e.*, "seed" produced from a second crop planted in August and harvested in November) is much more productive than "seed" saved from the summer crop, and that whole sets are superior to cut sets in the case of summer grown "seed." With regard to whole *v.* cut sets in the case of winter grown "seed," the results of the experiments made in 1911 and 1912 were contradictory, the 1911 experiments indicating that cut sets were more productive, while in 1912 the results were decidedly in favour of whole sets. For this reason the experiments were repeated in 1913.

As in former years the experiments were divided into two series. In one series the same numbers of sets were used, but the weight of cut sets was only about half that of the whole sets, while in the second series the sets were approximately equal both in number and weight. This year, in addition to the plots in each series being duplicated, the experiment was carried out with two varieties, *viz.*, "King of Potatoes" and "Magnum Bonum" instead of with only one variety. Each plot was 1-40th acre in area and was manured with 300 mds. of cowdung and 10 mds. of rape cake per acre.

The following tables give the results obtained in 1913:—

SERIES I.

*Equal numbers of sets—seed rate of whole sets 12 maunds and of cut sets 6 maunds per acre.*

Kind of sets used.	Magnum Bonum.		King of Potatoes.		Average of two varieties.
	Yield per acre.	Average.	Yield per acre.	Average.	Per acre.
Cut sets (winter seed) ... ..	Mds. 177	} 177½ {	Mds. 161	} 170	173½
Ditto ditto ... ..	178		179		
Whole sets (winter seed) ... ..	202	} 192 {	171	} 174	183
Ditto ditto ... ..	182		177		
Cut sets (summer seed) ... ..	90	} 69½ {	89	} 103	86½
Ditto ditto ... ..	49		117		
Whole sets (summer seed) ... ..	137	} 145 {	121	} 128	136½
Ditto ditto ... ..	153		135		

## SERIES II.

*Equal numbers and equal weights—seed rate 12 maunds per acre.*

Kind of sets used.	Magnum Bonum.		King of Potatoes.		Average of two varieties.
	Yield per acre.	Average.	Yield per acre.	Average.	Per acre.
	Mds.	Mds.	Mds.	Mds.	Mds.
Cut sets (winter seed) ...	194	} 182½ {	172	} 175	178½
Ditto ditto ...	171		17		
Whole sets (winter seed) ...	183	} 175½ {	167	} 163	171½
Ditto ditto ...	168		169		
Cut sets (summer seed) ...	106	} 101½ {	92	} 103	102½
Ditto ditto ...	97		114		
Whole sets (summer seed) ...	129	} 116½ {	100	} 115	115½
Ditto ditto ...	104		130		

Winter "seed" in every case again shows an enormous superiority over summer "seed." In the case of summer "seed" whole sets appear to be preferable to cut sets, while for winter seed there is not very much difference. The most remarkable fact brought out by these figures, however, is that the yields in the case of cut sets have not been diminished to any very great extent by halving the weight of seed planted. The question of seed rate evidently needs further investigation; this will be taken up next year in order to determine the optimum seed rate for both whole and cut sets.

Experiments with winter versus summer seed will be discontinued in view of the definite results already obtained.

10. This is not strictly speaking a potato-manuring experiment. It is intended to compare the effect of cow-dung alone and cowdung plus insoluble phosphates on limed and unlimed areas, through the following rotation:—

1st year Potatoes.

2nd ,, Maize.

3rd ,, Soybeans.

The plan of the experiment is as follows, each plot being  $\frac{1}{10}$ th acre in area :—

Plot No. ... ..	Lime. 6 5 4 3 2 1	No lime. 6 5 4 3 2 1
Plot No. ... ..	No lime. 6 5 4 3 2 1	Lime. 6 5 4 3 2 1

Slaked lime was applied at the rate of 10 maunds per acre about a month before the crop was planted, and the following manures were applied in the drills at the time of planting :—

Plots 1 and 4—300 maunds of cowdung per acre.

„ 2 and 5—300 maunds of cowdung plus 3 maunds of Flour phosphate per acre.

„ 3 and 6—300 maunds of cowdung plus 3 maunds of raw Bonemeal per acre.

The Flour phosphate and Bonemeal were mixed with the cowdung before application. Half the area was planted with King of Potatoes and the other half with Magnum Bonum potatoes at the rate of 10 maunds per acre.

The following tables show the first year's results :—

*King of Potatoes—Maunds per Acre.*

Plots.	Manuring.	Limed.		Average.	Non-limed.		Average.
		Duplicate plot.	Duplicate plot.		Duplicate plot.	Duplicate plot.	
1 and 4	300 mds. cowdung per acre.	141	95	118	136	112	124
2 and 5	300 mds. cowdung per acre plus 3 mds. Flour phosphate per acre.	127	125	126	139	114	26 $\frac{1}{2}$
3 and 6	300 mds. cowdung per acre plus 3 mds. Bonemeal per acre.	142	131	136 $\frac{1}{2}$	126	112	119



*Magnum Bonum—Maunds per Acre.*

Plots.	Manuring.	Limed.		Average.	Nonlimed.		Average.
		Duplicate plot.	Duplicate plot.		Duplicate plot.	Duplicate plot.	
1 and 4	300 mds. cowdung per acre.	101	91	96	109	67	98
2 and 5	360 mds. cowdung per acre plus 3 mds. Fluor phosphate per acre.	102	109	105½	109	106	107½
3 and 6	300 mds. cowdung per acre plus 3 mds. Bone meal per acre.	112	115	114	116	115	115½

These experiments will have to be carried on for a number of years before reliable results can be obtained. It was not expected that the manurial dressings in addition to cowdung would shew up on the first potato crop, but next year the phosphates should benefit the maize crop, and in the following year the soybeans should shew the effect of both phosphates and lime.

11. When harvesting the winter crop it had often been observed that many of the original sets were still sound, and when allowed to remain in the ground resulted in a large number of "self sown" potatoes. This year for the first time  $\frac{1}{10}$ th acre was planted with old sets of King of Potatoes which had already produced the winter crop. The result was rather astonishing, the yield from the old tubers being at the rate of 150 maunds per acre, which is above the average yield for the whole of the potato crop on the farm this year.

Although we would not advise people to make a regular practice of using old sets, still the above experiment shews that old sets might be used with advantage when the supply of new sets runs short.

12. From the 1912 crop, 605 maunds of King of Potatoes and Magnum Bonum were sold to cultivators for "seed" at a concession rate of Re. 1-8 per maund in order to advertise our superior "seed," the average bazar rate for potatoes being about Rs. 2 per maund. This year we grew  $6\frac{1}{4}$  acres of King of Potatoes producing 600 maunds of "seed" and  $3\frac{3}{4}$ th acres of Magnum Bonum producing 438 maunds of "seed." Practically the whole of this is being sold to cultivators at Rs. 3-4 per maund, which is the average bazar rate this season.

In addition to this, over 100 maunds of King of Potatoes, 90 mds. of Magnum Bonum and smaller quantities of the other varieties produced on the experimental areas will be reserved for planting on the farm for the production of winter seed.

The manuring in the non-experimental areas was only 150 mds. of cowdung and 10 mds. of rape cake per acre, hence the smaller yields.

13. Two acres of newly reclaimed marsh land was put under rice. The land was laid out in  $\frac{1}{8}$ th acre plots which were treated as follows:—

Rice Experiments,

Plot No I.—No Manure.

„ „ II.—3 mds. Flour phosphate per acre.

„ „ III.—No manure.

„ „ IV.—3 mds. Bonemeal per acre.

„ „ V.—No Manure.

Plots VI to X are duplicates of I to V. The plots subsequently had to be divided into  $\frac{1}{16}$ th acre areas in order to facilitate irrigation. Half the area was sown with rice broadcast in the ordinary local way, the seed rate being 100lb per acre, and on the other half transplanting was tried with single plants about 6 inches apart, the seed rate required being only 25lb per acre. The transplanting of paddy is never practised in the higher valleys, the crop being always sown broadcast, with the result that a heavy seeding is required. If it were possible to substitute transplanting for broadcasting, there would be a saving of at least 75 per cent. in the seed rate. Another point in favour of transplanting is that it would tend to check the ravages of an insect named "Paintaphi"\* (local) which eats the young paddy shoots, as the small areas of seed beds would be more easily controlled than the wide stretches of broadcasted land. This insect has been found to attack only very young plants, so transplanted paddy would probably be immune.

The experiment will be carried on for a number of years until reliable results are obtained. As the crop will not be harvested until November, the first year's results will be given in the next annual report.

14. The following were tried in the Autumn of 1912:—

*Radishes.*—About an acre was sown in September, local seed being used. The total yield of green fodder and roots was 118 maunds, of which the greater part was fed to the sheep throughout the cold weather, a small quantity of roots being sold as vegetables.

Trials of Fodder  
Crops.

*Oats and Peas.*—Seed from the plains was sown on about 3 acres partly as mixed and partly as pure crops. Germination was fairly good, but heavy rain in October destroyed the crop.

*Rape.*—Seed from the plains was sown on  $\frac{1}{2}$  acre in August. Germination was good, but the crop was battered by rain and was practically a failure.

*Perennial Rye Grass and Alsike Clover.*—Seed obtained from Sutton's (England) was sown mixed on  $\frac{1}{10}$ th acre in August. Both germinated well, but the Clover failed owing to heavy rain. The Rye Grass grew fairly well and is now seeding. The same happened in the case of Spring sowings.

The following were sown in the Spring of 1913:—

*Lupins.*—Seed was originally obtained from Sutton's last year. With the seed saved from last year's crop about  $\frac{1}{10}$ th acre was sown in May. The crop is doing well.

*Darjeeling Soybean.*—Sown on about  $\frac{1}{10}$ th acre in May is doing fairly well.

*Buckwheat.*—About  $\frac{1}{10}$ th acre was sown in May with seed obtained from Nepali settlers. Germination was good and the crop is doing well.

*Cowpeas.*—Seed obtained from Rajshahi (Bengal) was sown on  $\frac{1}{10}$ th acre in May. Germination was good, but the crop subsequently died out.

*Swedes.*—About  $\frac{1}{10}$ th acre was sown in May with seed obtained from Sutton's. The land was manured with 300 maunds cowdung, 3 maunds Bonemeal and 3 maunds Flour phosphate per acre. Germination was good and the crop has made fair progress, but from the size of the roots at present it does not appear that the crop will be very productive. Still it appears to stand the heavy rains better than turnips.

*Turnips.*—These were sown at the same time as the Swedes on land manured similarly. The crop is not doing at all well.

*Mangels and Sugar beet.*—Were sown in May, but failed to germinate.

*Lucerne.*—Seed obtained from England was sown in May. Germination was poor and heavy rain destroyed the few plants which germinated.

*Jowar.*—Seed obtained from the plains was sown on  $\frac{1}{10}$ th acre. Germination was poor and the crop failed.

*Sword beans and Florida Velvet beans.*—Seed was obtained from America and sown in June on small areas. Both germinated well, but the plants are stunted. The climate appears to be too wet and cold for these crops.

*Trydip grass.*—This is a good local fodder grass. Another attempt was made this year to grow it from seed on about  $\frac{1}{10}$ th acre. Germination was good, and the experiment is likely to be successful.

*Australian grasses and Clovers.*—Eight varieties of grasses and three of Clovers were obtained from Australia and sown mixed on about  $\frac{2}{3}$ ths acre. Each variety was also sown pure on a small plot. The seeds germinated fairly well, but all the young plants were destroyed by heavy rain in June and July.

Several attempts have now been made to introduce exotic fodder crops, and the result on the whole has been a decided failure. The climate conditions at this elevation are peculiar, the rainfall being very heavy between April and September, and scanty during the rest of the year. The winter is dry and cold, frosts occurring almost nightly from November till March, but snow falls very rarely, perhaps once in 10 years or so. The summer climate with its torrential rains does not suit English crops, and the winter is too cold and dry for them. We have, therefore, come to the conclusion that it would be useless to continue experiments with English fodder crops. Fortunately Maize grows well in these hills in the rains, and with this for silage, and *Raishan* (a local small millet) and indigenous soy-beans for hay, we are not dependent on the introduction of crops for winter fodder.

15. *American Maize.*—Seed of 5 varieties was saved from last year's crop and sown on small plots separately in different parts of the farm. Only two of the varieties, *vis.*, Early Huron Dent and Reid's Yellow Dent are doing well; the remainder germinated badly and subsequently suffered from the attacks of cut worms.

*Rhubarb.*—About  $\frac{1}{10}$ th acre was planted in October 1912, with plants removed from the fruit garden. The crop is flourishing.

*Asparagus.*—Plants from the fruit garden were put down on about  $\frac{1}{3}$ rd acre in October 1912. The crop is doing well and should give cuttings next year.

*Straubberries.*—Nine varieties, removed from the fruit garden in October 1912, were planted on about  $\frac{1}{10}$ th acre. The season was too late for transplanting and consequently very few plants survived. The blanks have been filled up by suckers.

16. With a view to the isolation of superior varieties of local maize, a single cob (as nearly perfect as possible) of each of the following varieties was collected from the surrounding villages :—

Selection Experi-  
ments.

Dembah.	Dem lieh.
Dem lynnep.	Dem saw.
Dem krai.	Dem Mylliem.
Dem sohriew.	Dem Synting.

A hundred seeds of each cob were sown separately on small plots in different parts of the farm. It remains to be seen whether all or any of these varieties are pure. It is proposed to evolve pure strains if possible and to attempt to improve them by selection.

Small quantities of "Job's tears" (a local millet) and "Soh-plang" have been sown with the same object.

17. The following quantities of green fodder were ensiled in

Fodder crops for  
Silage and Hay. the Autumn of 1912 :—

—	Pucca silo.	Pit silo.	Total.
1	2	3	4
	Mds.	Mds.	Mds.
Maize ... ..	487½	719½	1,157
Langtylli grass ... ..	61	...	61
Wild grasses ... ..	20½	146½	166½
<b>Total ensiled ...</b>	<b>518½</b>	<b>866</b>	<b>1,384½</b>
<b>Total recovered as good silage ...</b>	<b>294½</b>	<b>535½</b>	<b>830½</b>
	(57 per cent.)	(62 per cent.)	(60 per cent.)

The *pucca* silo built some years ago is semi-circular in section. This shape is a mistake, as the silage always goes bad in the corners. The pit silo was made as an experiment last year. It is cylindrical, being 14 feet in diameter by 11 feet deep. The cost of construction, including a thatched roof, was only Rs. 34. From the percentage of good silage obtained from the pit silo it will be seen that it is more efficient than the semi-circular *pucca* silo. In fact there appears to be no need to go to the expense of a *pucca* building when such good results can be obtained by simply digging a pit. A good high site should be chosen for a pit silo where there is no chance of drainage water filtering in. The top of a hillock is an excellent place.

In addition to silage, about 290 maunds of *Raishan* and Soybean hay was made and fed to the cattle and sheep during the winter.

This year about 15 acres has been sown with maize for silage. The crop is not doing so well as usual owing to the unfavourable season. About 25 acres has been sown with *Raishan*, five acres with Soybeans, and two acres with Soybeans and *Raishan* mixed for hay. About half of this, sown on newly-reclaimed land, is not doing well.

18. The following table shows the number of cattle in the Cattle breeding herd on 30th June 1913 :—

	Paina.	Bhatia.	P × B.	P × B × P.	P × Khaal.	P × K × P.	Total.	Remarks.
1	2	3	4	5	6	7	8	9
Breeding bulls ...	2	...	...	...	...	...	2	
Bulls (3 years and above)	1	...	...	...	2*	6	9	* Are being used as plough cattle.
" (2 to 3 years) ...	3	...	...	1	...	...	4	
" (1 to 2 years) ...	3	...	...	3	...	...	6	
" (under 1 year) ...	5	...	1	...	...	...	6	
Heifers (2 to 3 years) ...	2	...	1	1	...	...	4	
" (1 to 2 " ) ...	1	...	...	4	...	...	5	
" under one year	1	...	...	3	...	...	4	
Cows ...	9	1	5	1	...	...	16	
Total ...	27	1	7	13	2	6	56	

In addition to the above, there are 3 Hindustani and 8 Khasi bullocks. The total number of cattle on the Farm was, therefore,

67. During the year 10 animals were born, *viz.*:—

5 Patna bull calves.

1 Patna × Bhutia bull calf.

1 Patna heifer calf.

3 Patna × Bhutia × Patna heifer calves.

There were 5 deaths, *viz.*:—

1 Patna bull calf.

1 Patna × Bhutia bull calf.

3 Patna heifer calves.

Twenty-three animals were sold during the year, *viz.*:—

Patna bulls ... { 7 (for breeding purposes).  
3 (1—2 years rejected from herd).

Patna × Khasi bulls { 5 (for breeding purposes).  
1 (rejected from herd).

Patna × Bhutia bulls 3 (rejected from herd).

Patna × Bhutia × Patna bulls 1 (rejected from herd).

Bhutia cows 2.

Hindustani bullock 1.

The pure bred bulls were sold at Rs. 50 each and the cross bred at Rs. 40 each. Four went to the plains and the remainder were taken by Khasi cultivators.

The rejected bulls were sold locally for a lump sum of Rs. 145. Some were castrated to be trained as work cattle, and others were slaughtered for beef. These were all "weeds" which would never have been any use for breeding purposes.

The two Bhutia cows and the Hindustani bullock were cast for old age. The Bhutia cows fetched Rs. 40 each and the Hindustani bullock Rs. 25.

The sale price of the breeding bulls is obviously much too low, but we have to sell at concession rates in order to make it possible for the small cultivator to purchase. The pure bred 3-year old Patna bulls sent out from the Farm should be worth at least from Rs. 200 to Rs. 300 each to the purchasers, but it is impossible to realize their full value for the above reasons.

19. With the object of improving the local breed of sheep an experiment was commenced in 1909 with a Dumba ram and 5 Khasi ewes. By the 30th June 1910 the flock had increased to 15. In 1911 two more Dumba rams and 45 Khasi ewes were purchased. In June 1912 the total number of sheep was 136. During the year under report 4 Dumba rams and 11 ewes and ewe lambs were imported.

On 30th June 1913 the total number of sheep on the Farm was 171, made up as follows:—

Dumba rams	...	...	...	5
Dumba ewes	...	...	...	10
Khasi ewes	...	...	...	63
Khasi rams	...	...	...	6
Dumba × Khasi rams	...	...	...	4
Dumba × Khasi ewes	...	...	...	17
Dumba × Khasi ram lambs	...	...	...	26
Dumba × Khasi ewe lambs	...	...	...	21
Dumba × Khasi × Dumba rams	...	...	...	3
Do. do. do. ewe	...	...	...	1
Do. do. do. ram lambs	...	...	...	9
Do. do. do. ewe lambs	...	...	...	6
				<hr/>
				171
				<hr/>

95 lambs were born during the year, viz. :—

Dumba × Khasi ram lambs	...	...	42
Dumba × Khasi ewe lambs	...	...	30
Dumba × Khasi × Dumba ram lambs	...	...	16
Do. do. ewe lambs	...	...	7
			<hr/>
			95
			<hr/>

There were 56 deaths, viz. :—

Khasi ewes	...	...	17 (mostly of oldage).
Khasi rams	...	...	4
Dumba × Khasi ram	...	...	2
Dumba × Khasi ram lambs	...	...	16
Do. ewe lambs	...	...	9
Dumba × Khasi ewes	...	...	4
Dumba × Khasi × Dumba ram lambs	...	...	2
Dumba × Khasi × Dumba ewe lambs	...	...	1
Dumba ewe	...	...	1
			<hr/>
			56
			<hr/>



The following were sold to Khasi cultivators:—

Dumba × Khasi rams 4 @ Rs. 8 each.

Dumba × Khasi × Dumba rams 2 @ Rs. 10 each.

The mortality was heavy. Out of 95 lambs born, 28 died. The majority of deaths occurred in November on a cold wet day. The young cross bred lambs can stand the cold, but a wet day in the cold weather is fatal to the weaker ones, unless they can be brought under shelter before it starts to rain.

The 17 Khasi ewes which died were all very old and their deaths were not unexpected.

In former years most of the cattle and sheep were sent down to Sumer (elevation about 2,000 feet) during the winter for grazing. Last winter, for reasons stated in last year's report, this practice was discontinued, and all the farm stock were kept at the farm throughout the winter.

The experiment was entirely successful, both cattle and sheep being in better condition at the end of last winter than ever before. This was due to the ample supply of silage and hay available at the farm last season.

20. The establishment consists of a Farm Superintendent on Rs. 100—10—200, a Fieldman clerk on Rs. 50, a mali on Rs. 12 and a peon on Rs. 9 per mensem.

There are three apprentices under practical training on Rs. 15 per mensem. One of these is a Lushai boy who has been sent for training by the Superintendent of the Lushai Hills.

There is also an Overseer on Rs. 40, but he is employed almost entirely in supervising the demonstration work in the Khasi and Jaintia Hills district. To assist him in this work three demonstrators on Rs. 25 per mensem are employed. These demonstrators received two years' practical training on the farm as apprentices.

Mr. Herrick Singh continued to act as Farm Superintendent. Babu Rukhmini Mohan De acted as Fieldman clerk until May when he was appointed Superintendent of the new Experiment Station at Karimganj (Sylhet), and Mr. Lewis Reade was appointed in his place.

Two apprentices, one a Khasi and the other a Lushai, completed their two-year course of practical training during the year. The Khasi (U Millison) has since been appointed temporary demonstrator on Rs. 25 per mensem.

The staff worked well during the year. Mr. Herrick Singh and his brother Mr. Harry Singh both did good work, the former in carrying out the experimental work on the Farm and the latter in supervising the demonstration work in the district.

21. The total receipts were Rs. 3,889, of which Rs. 567 was by sale of milk, Rs. 940 by sale of cattle and Rs. 812 by sale of potatoes. Of the balance, Rs. 440 was by sale of bonemeal, and this should be deducted from the Farm receipts, leaving a total of Rs. 3,449.

The expenditure amounted to Rs. 20,600. This includes Rs. 2,518 for establishment and Rs. 5,703 for capital charges (mainly construction of quarters and reclamation).

The cost of cattle and sheep breeding was as follows:—

	Rs.
Purchased foods ... ..	4,778
Value of Farm produce fed ... ..	641
Wages of attendants ... ..	2,040
Miscellaneous ... ..	103
Total ... ..	7,562

The total expenditure this year was unusually high owing to the large amount spent on buildings and reclamation.

The most expensive item is undoubtedly the cost of the cattle and sheep breeding operations, and I am not satisfied that the figures given (Rs. 7,562) adequately represent the whole cost. The large amount spent on petty repairs (about Rs. 1,000) was mostly on account of the cattle and this has not been included. Again the greater part of the amount spent (about Rs. 1,708) on reclamation was on account of the cattle, owing to the necessity of extending the cultivated area for the growth of fodder crops. Then again there is the cost of experimenting with fodder crops.

We may take it that the actual recurring cost of the cattle and sheep is from Rs. 8,000 to Rs. 9,000 per annum.

The result of this expenditure is the distribution of about 10 or 12 breeding bulls and perhaps a dozen or so rams annually. Of course the amount of good done cannot be measured by the actual money value of the animals sold, yet it would probably be well to consider whether it is worth while maintaining the herd at such great expense.

Practically the only other work of any very great importance being carried out on the Farm at present is the growing of potatoes, and this is probably of much more value than the cattle and sheep breeding operations.

The manure obtained from the cattle and sheep is largely used for potato growing, and when considering the question of the cost of the up-keep of the herd, this important point should not be overlooked. If the herd was abolished we should find great difficulty in obtaining sufficient cowdung for the potato crop, and for this reason, in addition to the good done by improving local stock, there appears to be a good case for maintaining the herd for the present at any rate.

*Shillong,*  
*The 10th September 1913.* }

A. G. BIRT,  
*Deputy Director of Agriculture, Assam.*

REPORT OF THE FRUIT EXPERIMENT STATION,  
SHILLONG, FOR THE YEAR ENDING ON THE 30TH  
JUNE 1913.

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1. Land of the unclassified State forest situated on the south side of the Jowai road was selected in July 1912 for the site of the fruit garden. Its elevation is about 5,100 feet, distant about a mile from the town. It comprises an area of 35.6 acres, of which 15 to 20 acres is suitable for fruit planting. Work commenced in October 1912. A block of 5 acres of the forest on the lowest level was selected for the first year's planting and has been fenced with Page's wire fencing. Of this area, the soil on about  $3\frac{1}{2}$  acres was found of suitable nature for planting. The soil varies from light sandy loam lying above stone to a heavier loam of good depth. The varieties planted were selected to, as far as possible, suit the soil they were to be planted in, but some may have to be transplanted if they do not thrive in their present position. Virgin soil in a pine forest would doubtless benefit by being left exposed for some time after clearing before planting, but the deep trenching done and application of lime greatly improved it. The young trees are healthy and are beginning to put on a good growth. Atmosphere has as much to do with the results as has the soil, and success cannot be looked for in Shillong until it is known what varieties will thrive. An experimental planted area of 10 acres will be necessary for this purpose. Insects, blights and the diseases fruit trees are attacked with, can be contended with. From the 5 years' experience of fruit growing I have had in Shillong, I consider that rabbits, birds, wasps and similar pests that other countries have to contend against, would give as much trouble as do the beetles and flies, the chief enemies of fruit trees in Shillong. Blights and diseases are no worse than in other countries, and if fought against from the commencement by spraying can be overcome. Certain properties where wanted will have to be added to the soil. The experiments made with Superphosphate of Lime, Sulphate of Potash and Sulphate of Ammonia will be carefully watched. The fruit trees were purchased from Messrs. Thomas Rivers & Sons, Sawbridgeworth, Herts, and Messrs. Stuart Low & Company, Bush Hill Park, Middlesex. Messrs. Rivers' first consignment was despatched on the 12th

November 1912 and arrived at Shillong on the 21st January 1913. There was delay in getting delivery at the docks in Calcutta. The pear, cherry and peach trees suffered most, and in consequence have been considerably set back—98 per cent. of the trees have recovered. Messrs. Stuart Low & Company's consignment despatched on the 19th December 1912 arrived in very good condition on the 8th February 1913. A second small consignment from Messrs. Rivers despatched 26th February 1913 arrived on the 1st May 1913; the delay of a week at the London Docks unfortunately gave a severe check to the trees. Six cherry and six peach trees arrived dead; the majority of the rest of the trees survived and have been planted out. Planting commenced on the 27th January 1913 and was finished on the 8th May 1913. The bush and pyramid trees have been planted 15ft. × 15ft. diagonally, the upright trained trees 7ft. apart and the single cordon trees 2ft. apart at an angle of 60°. The standard and horizontal trained apple trees and the orange and lemon trees have been planted in suitable situations.

2. The following statement shows the number and varieties of fruit trees planted :—

Varieties planted.

Species of Fruit trees.	Variety.	Whence obtained.		Total number.	Description.
		Messrs. Thomas Rivers and Sons, Herts.	Messrs. Stuart Low & Co., Middlesex.		
Apple trees	Lady Sudeley ...	6	...	6	Bush.
Ditto ...	Bismarck ...	6	...	6	"
Ditto ...	Sturmer Pippin ...	5	4	9	"
Ditto ...	Warners King ...	12	...	12	"
Ditto ...	Potts Seedlings ...	6	4	10	"
Ditto ...	Alfriston ...	6	4	10	"
Ditto ...	Scarlet Nonpareil ...	12	4	16	"
Ditto ...	Newton Wonder ...	6	4	10	"
Ditto ...	Norfolk Beauty ...	6	4	10	"
Ditto ...	Lanes Prince Albert ...	6	4	10	"
Ditto ...	Juneating (Red) ...	6	4	10	"
Ditto ...	Bens Red ...	5	4	9	"
Ditto ...	Coe's Golden drop ...	6	...	6	"
Ditto ...	Kerry Pippin ...	6	4	10	"

Species of Fruit trees.	Variety.	Whence obtained.		Total number.	Descrip- tion.
		Messrs. Thomas Rivers and Sons, Herts.	Messrs. Stuart Low & Co., Middle- sex.		
Apple trees	Golden Reinette	6	...	6	Bush.
Ditto ...	Branley's Seedlings	10	4	14	"
Ditto ...	Fearn's Pippin	6	...	6	"
Ditto ...	Devonshire Quarrenden	12	6	18	"
Ditto ...	James Grieve	36	12	48	"
Ditto ...	Peasgood Nonesuch	6	...	6	"
Ditto ...	Yellow Ingestre	6	...	6	"
Ditto ...	Roundway Magnum Bonum	6	...	6	"
Ditto ...	Grimson Bramley	...	5	5	"
Ditto ...	Ardcairn Russet	...	5	5	"
Ditto ...	Rev. W. Wilks	...	6	6	"
Ditto ...	William Crump	...	6	6	"
Ditto ...	Hounslow Wonder	...	6	6	"
Ditto ...	Red Victoria	...	10	10	"
Ditto ...	Hector McDonald	...	10	10	"
Ditto ...	Herrings Pippin	...	1	1	"
Ditto ...	Ellison Orange	...	1	1	"
Ditto ...	Charles Eyre	...	1	1	"
Ditto ...	Rymer	8	...	8	Standards
Ditto ...	Stirling Castle	5	...	5	"
Ditto ...	Northern Greening	9	...	9	"
Ditto ...	Scarlet Golden Pippin	2	...	2	Upright trained.
Ditto ...	Allington Pippin	2	...	2	Ditto.
Ditto ...	Beauty of Bath	2	...	2	Ditto.
Ditto ...	James Grieve	2	...	2	Ditto.
Ditto ...	Barnaek Beauty	2	...	2	Ditto.
Ditto ...	King of the Pippins	2	...	2	Horizon- tal train- ed.
Ditto ...	Coxs Orange Pippin	1	...	1	Ditto.
Ditto ...	Kerry Pippin	1	...	1	Ditto.
Ditto ...	Claygate Pearmain	1	...	1	Ditto.
	Total	220	112	332	

Species of Fruit trees.	Variety.	Whence obtained.		Total number.	Description.
		Messrs. Thomas Rivers and Sons, Herts.	Messrs. Stuart Low & Co., Middlesex.		
Pear trees	Emile d' Heyst ...	10	...	10	Pyramid
Ditto ...	Fondant Thirriot ...	10	...	10	Ditto.
Ditto ...	Madame Treyve ...	10	...	10	Ditto.
Ditto ...	St. Swithins ...	10	...	10	Ditto.
Ditto ...	Clapps Favourite ...	10	...	10	Ditto.
Ditto ...	Hessle ...	13	...	13	Ditto.
Ditto ...	Red October ...	10	...	10	Ditto.
Ditto ...	Beurre d' Amanlis ...	10	...	10	Ditto.
Ditto ...	Parrot ...	10	...	10	Ditto.
Ditto ...	Seedling Bergamot ...	6	...	6	Ditto.
Ditto ...	Josephine de Malines ...	10	...	10	Ditto.
Ditto ...	Dr. Hogg ...	10	...	10	Ditto.
Ditto ...	Fertility ...	20	...	20	Ditto.
Ditto ...	Bacon ...	10	...	10	Ditto.
Ditto ...	Durondeau ...	6	...	6	Ditto.
Ditto ...	Beurre de Naghan ...	...	6	6	Ditto.
Ditto ...	St. Jules Guyot ...	...	6	6	Ditto.
Ditto ...	Roosevelt ...	...	6	6	Ditto.
Ditto ...	Blickling ...	...	6	6	Ditto.
Ditto ...	Santa Claus ...	...	6	6	Ditto.
Ditto ...	Precoce de Juillet ...	...	6	6	Ditto.
Ditto ...	Conference ...	3	...	3	Upright trained
Ditto ...	Marie Louise d' Uccle ...	4	...	4	Ditto.
Ditto ...	Louise Bonne of Jersey ...	4	...	4	Ditto.
Ditto ...	Fondant d' Automne ...	3	...	3	Ditto.
Ditto ...	Conseiller de la Cour ...	3	...	3	Ditto.
Ditto ...	Doyenne du Comice ...	3	...	3	Ditto.
Ditto ...	Louise Bonne of Jersey ...	5	...	5	Single Cordon
Ditto ...	Conference ...	5	...	5	Ditto.
Ditto ...	Doyenne du Comice ...	5	...	5	Ditto.
Ditto ...	Williams bon Chretien ...	5	...	5	Ditto.
Ditto ...	Marguerite Marillar ...	5	...	5	Ditto.
Ditto ...	Beurre Superfin ...	5	...	5	Ditto.
Ditto ...	Princess ...	5	...	5	Ditto.
Ditto ...	Beurre Diel ...	5	...	5	Ditto.
Ditto ...	Beurre Hardy ...	5	...	5	Ditto.
Ditto ...	Beurre d' Anjou ...	5	...	5	Ditto.
	Total ...	225	36	261	

Species of Fruit trees.	Variety.	Whence obtained.		Total number.	Description.
		Messrs. Thomas Rivers and Sons, Herts.	Messrs. Stuart Low & Co., Middlesex.		
Plum trees	Deniston's Superb Gage ...	10	...	10	Brush.
Ditto ...	Pelle de Louvain ...	6	...	6	Ditto.
Ditto ...	Cox's Emperor ...	6	...	6	Ditto.
Ditto ...	Ponds Seedling ...	6	...	6	Ditto.
Ditto ...	Belgian Purple ...	10	...	10	Ditto.
Ditto ...	Early Transparent ...	6	...	6	Ditto.
Ditto ...	Autumn Beauty ...	6	...	6	Ditto.
Ditto ...	Guthrie's late Gage ...	5	...	5	Ditto.
Ditto ...	Reine Claude de Bavay ...	5	...	5	Ditto.
Ditto ...	Victoria ...	9	...	9	Ditto.
Ditto ...	Grœngage ...	5	...	5	Ditto.
Ditto ...	Czar ...	6	...	6	Ditto.
	Total ...	80	...	80	
Peach trees	Peregrine ...	14	...	14	Ditto.
Ditto ...	Alexander ...	11	...	11	Ditto.
Ditto ...	Duke of York ...	16	...	16	Ditto.
Ditto ...	Exquisite ...	4	...	4	Ditto.
	Total ...	45	...	45	
Cherry trees	Morello ...	3	...	3	Ditto.
Ditto ...	Kentish ...	24	...	24	Ditto.
Ditto ...	Bigarreau Kentish ...	6	...	6	Ditto.
Ditto ...	Gloire de France ...	6	...	6	Ditto.
Ditto ...	White Heart ...	...	6	6	Ditto.
Ditto ...	Black Heart ...	..	6	6	Ditto.
	Total ...	39	12	51	
Fig trees	White Marseilles ...	5	...	5	Ditto.
Ditto ...	Bourjassotte Grise ...	5	...	5	Ditto.
Ditto ...	Monaco Bianco ...	6	...	6	Ditto.
	Total ...	16	...	16	



Species of Fruit trees.	Variety.	Whence obtained.		Total number.	Description.
		Messrs. Thomas Rivers and Sons, Herts.	Messrs. Stuart Low & Co., Middlesex.		
Walnut trees.	Dwarf Prolific ( <i>Juglans procaryptariensis</i> ).	10	...	10	Trees.
Lowberries	.....	...	6	6	Berries.
Phenomenal	.....	...	1	1	Ditto.
Loganberries	... ..	...	1	1	Ditto.
Orange trees.	St. Michael's Tangierin ...	6	...	6	Trees.
Ditto ...	Jaffa ... ..	3	...	3	Ditto.
Ditto ...	Malta Blood ... ..	2	...	2	Ditto.
Ditto ...	Silver ... ..	3	...	3	Ditto.
Ditto ...	Sustain ... ..	1	...	1	Ditto.
Ditto ...	Malta Oval ... ..	1	...	1	Ditto.
Ditto ...	Achilles ... ..	1	...	1	Ditto.
	Total ... ..	17	...	17	
Lemon trees	Imperial Lemon ... ..	2	...	2	Ditto.
Strawberry Plants.	Givons date Prolific ... ..	...	...	900	Plants.
Ditto ...	Louis Gauthier ... ..	...	...	350	Ditto.
	Total ... ..	...	...	1,250	

## SUMMARY OF FRUIT TREES PLANTED—1912-13.

Standard apple trees	...	...	...	22
Bush	...	...	...	295
Upright trained	...	...	...	10
Horizontal	...	...	...	5
Pyramid pear trees	...	...	...	191
Upright trained	...	...	...	20
Single cordon	...	...	...	50
Plum trees	...	...	...	80
Peach	...	...	...	45
Cherry	...	...	...	51
Fig	...	...	...	16
Dwarf walnut trees	...	...	...	10
Lowberies	...	...	...	6
Phenomenal	...	...	...	1
Loganberries	...	...	...	1
Orange trees	...	...	...	17
Lemon	...	...	...	2
Strawberry plants	...	...	...	1,250

3. The following experiment with manures have been carried out. The quantities were applied in two dressings at an interval of 6 weeks, in a circle 4 feet wide round the trees, starting 5 inches from the stem.

James Grieve Apples.

4 rows—5 trees in each row.

Row No.

Manures per tree.

1 ... ..  
2 ... ..  
3 ... ..  
4 ... ..

6 ozs. Superphosphate.  
4 „ Sulphate of Potash.  
3 „ Sulphate of Ammonia.  
6 „ Superphosphate.  
3 „ Sulphate of Ammonia.  
4 „ Sulphate of Potash.  
3 „ Sulphate of Ammonia.  
No manure.

Clapps Favourite Pear—

No. of plot.

No. of trees

Manures per tree.

1 ... 4 ...  
2 ... 3 ...  
3 ... 3 ...

6 ozs. Superphosphate.  
4 „ Sulphate of Potash.  
3 „ Sulphate of Ammonia.  
6 „ Superphosphate.  
3 „ Sulphate of Ammonia.  
No manure.

## Fertility Pear—

No. of plot.	No. of trees.
4 ...	4 ...
5 ...	3 ...
6 ...	3 ...

Manures per tree.	
6 ozs.	Superphosphate.
4 "	Sulphate of Potash.
3 "	Sulphate of Ammonia.
6 "	Superphosphate.
4 "	Sulphate of Potash.
4 "	Sulphate of Potash.
3 "	Sulphate of Ammonia.

## Madame Treyve Pear—

No. of plot.	No. of trees.
7 ...	4 ...
8 ...	3 ...
9 ...	3 ...

Manures per tree.	
6 ozs.	Superphosphate.
4 "	Sulphate of Potash.
3 "	Sulphate of Ammonia.
6 "	Superphosphate.
3 "	Sulphate of Ammonia.
No manure.	

## Emile Heyst Pear—

No. of plot.	No. of trees.
10 ...	4 ...
11 ...	3 ...
12 ...	3 ...

Manures per tree.	
6 ozs.	Superphosphate.
4 "	Sulphate of Potash.
3 "	Sulphate of Ammonia.
4 "	Sulphate of Potash.
3 "	Sulphate of Ammonia.
6 "	Superphosphate.
4 "	Sulphate of Potash.

C. H. HOLDER,

*The 29th June 1913.**In charge, Fruit Experiment Station,  
Shillong.**Statement of expenditure of the Fruit Experiment Station, Shillong, from  
November 1912 to 30th June 1913.*

Head of charges.	Amount.	Remarks.
	Rs.   s.   p.	
Allowance to Superintendent ...	1,250 0 0	
Establishment ...	481 0 5	
Petty construction ...	2,986 11 9	
Seeds, plants and manures ...	2,939 10 4	
Instruments, appliances and machinery ...	81 15 3	
Reclamation ...	70 14 0	
Chemicals insecticide ...	320 5 9	
Wages of labourers ...	7,499 2 7	
Other charges ...	4 2 0	
Total ...	15,633 14 1	

## R E P O R T

ON

## AGRICULTURAL DEMONSTRATIONS IN ASSAM

DURING THE YEAR ENDING

JUNE 30TH, 1913.

1. Demonstrations were carried out in four districts, *viz.*, Khasi and Jaintia Hills, Sibsagar, Sylhet and Kamrup.

In the Khasi and Jaintia Hills U Harry Singh was in charge of the work assisted by three demonstrators. The Agricultural Supervisor held general charge of the demonstrations in the Assam Valley, assisted by the District Agricultural Officer in Kamrup and by two demonstrators in Sibsagar. The District Agricultural Officer of Sylhet was in charge of the demonstrations in that district.

2. The advantage of using bonemeal as a manure for wet rice has been successfully demonstrated for several years in the Khasi and Jaintia Hills, the results showing a substantial profit notwithstanding the high price (Rs. 4-3 to Rs. 5 per maund) of bonemeal delivered in the hills. With an application of 3 maunds of raw bonemeal per acre, the increased yield in the first year is usually more than sufficient to pay the cost of the manure, while in the second and third years the increase is nett-profit.

The practice of manuring with bonemeal is steadily increasing among the hill people, and this year more than 200 maunds imported from Calcutta was sold to cultivators at from Rs. 4-8 to Rs. 5 per maund. The high price is, however, tending to check the extension of the practice. In view of this and in the absence of local enterprise, we have purchased a small bone-grinding plant, which will be installed shortly at Upper Shillong. Arrangements have been made for the supply of 1,000 maunds of bones, and next season we hope to be in a position to supply bonemeal at about Rs. 3 per maund delivered at Upper Shillong, leaving a small margin of profit as interest on capital.

During the year under report the results of paddy manuring demonstrations are available at two centres only in the Khasi Hills. The total number of manured plots was 19; these were alternated with 19 non-manured plots as a control. The aggregate area of manured plots was 0.6 acre, and of the controls the same.

The following results were obtained:—

	Yield.		Yield per acre.	
	Grain.	Straw.	Grain.	Straw.
	3	3	4	5
	Mds.	Mds.	Mds.	Mds.
Manured plots ... ..	13½	15	22½	25
Unmanured ... ..	10	11	17½	18
Increase due to manure ... ..	...	...	5½	6

The increase in grain was a little more than sufficient to cover the cost of the manure. The result on the first crop was quite satisfactory, as bonemeal never exerts its full effect in the first year, and heavier crops from the manured areas may be confidently expected in the second year.

A more extensive scheme of paddy manuring demonstrations was commenced during the year in four districts, Khasi and Jaintia Hills, Sibsagar, Sylhet and Kamrup. In each district 10 centres were selected on cultivators' holdings. Five plots, each approximately one *bigha* ( $\frac{1}{3}$  acre) in area, were taken and treated as follows:—

- (1) No manure.
- (2) Three maunds bonemeal per acre.
- (3) No manure.
- (4) Three maunds flour phosphate per acre.
- (5) No manure.

In Sylhet and Kamrup the demonstrations are mostly on "do fasl" land, *i.e.*, land from which two crops of paddy, one of *aus* and one of transplanted paddy, are taken annually. In Sibsagar the land is chiefly "ek. fasl," only one crop of

transplanted paddy being grown. In the Khasi and Jaintia Hills the land is also "ek fasi," but the crop is broadcasted instead of being transplanted as in the plains.

The first year's results of these demonstrations will not be available until December.

3. In the Sibsagar district, demonstrations were carried out at 12 centres. In each case B. 376 cane Sugarcane. from the Jorhat Farm was planted alongside the local varieties on cultivators' holdings. In nine centres equal areas of B 376 and the local varieties were taken for comparison, while in the remaining 3 centres, where the crops were badly injured by jackals and monkeys, an equal weight of B376 was compared with equal weights of the local varieties.

The weights of *gur* per acre were as follows :—

1	Centre.	Variety.	Gur per acre.	
			Mds.	sr.
1	Montgaon ...	B. 376 ...	62	15
		Magh ...	45	15
2	Naubalia gaon ...	B. 376 ...	63	15
		Magh ...	40	32
3	Kakilamukh ...	B. 376 ...	59	27
		Magh ...	48	13
4	Duliagassaingaon ...	B. 376 ...	75	21
		Magh ...	39	13
		Teli ...	30	10
		Dibrugarh Pounda ...	72	23
5	Jamuguri ...	B. 376 ...	46	15
		Magh ...	22	7
6	Panisukua ...	B. 376 ...	55	28
		Magh ...	22	27

Centres.		Variety.			Gur per acre.	
1	2	3			4	
7	Basagaon	...	...	B 376	Mds.	srs.
				...	49	6
8	Bamungaon	...	...	Magh	20	29
				B 376	56	28
9	Bernagaon	...	...	Teli	29	84
				B 376	21 24	} Plant- ed too late.
				Teli	16 8	

The results obtained by crushing equal weights of B 376 and the local varieties in the remaining three centres were as follows:—

Centres.		Variety.		Weight of cane.		Weight of juice.		Weight of gur.	
1	2	3		4		5		6	
				Mds.	srs.	Mds.	srs.	Mds.	srs.
10	Panichukua	...	...	B 376	9 20	6 18	1 10		
				Teli	9 20	5 10	0 39		
11	Dhuli	...	...	B 376	9 20	6 25	1 25		
				Magh	9 20	5 20	0 39		
12	Charaibari	...	...	B 376	10 15	7 0	1 10		
				Magh and Teli	10 15	6 15	1 0		

B 376 shows a marked superiority over the local varieties, Magh and Teli; yielding from 23 per cent. to 150 per cent. more gur, and averaging 83 per cent. more for the nine centres.

In No. 4 centre a variety locally known as "Dibrugarh Pounda" was practically as good as B 376. This variety is not generally grown by the Assamese, but is frequently found on the holdings of Nepali and up-country settlers. It was probably introduced by Marwari merchants, of whom there is a large colony at Dibrugarh.

In the crushing tests at centres Nos. 10 to 12, the advantage in favour of B 376 averages about 40 per cent. on the weight of *gur*.

These demonstrations have already begun to take effect, as this year there was a large demand for cuttings of the superior varieties grown at Jorhat, in fact far greater than we were able to meet.

In order to popularize the use of the 3 roller iron crushing mill in place of the old wooden mill still used to a great extent by the Assamese, six iron mills in charge of demonstrators were sent out in the Sibsagar district. One cultivator has since offered to purchase two of the mills and many others have expressed a desire to do so. The chief difficulty appears to be the initial outlay, which is about Rs. 60 for each mill. Most cultivators grow cane on only a very small scale and cannot afford to purchase a mill for their own use. There is apparently a good opening here for Co-operative Credit Societies to advance money for the purchase of mills. Probably the best system for small holders would be for one man to purchase several mills and hire them out to the neighbouring cultivators.

Next year it is proposed to send out at least 12 mills for demonstration purposes in various parts of the district.

4. The value of the superior varieties of potatoes grown at the Upper Shillong Farm is already recognised by the majority of cultivators in the Khasi Hills, with the result that there is a considerable demand for "seed." To meet this demand considerable areas of two of the best varieties, *viz.*, King of Potatoes and Maguüm Bonum were grown at the farm in 1912 and 1913. In 1912 635 maunds of "seed" of these varieties was sold. In 1913, a larger area was grown with the result that about 1,000 maunds of seed is available for sale. This is being sold at market rates at the farm and at four other centres in the hills.

In the Khasi Hills the value of spraying potatoes with Bordeaux mixture as a preventive of the potato disease (*Phytophthora infestans*) has been successfully demonstrated on cultivators' holdings for several years. The chief obstacle to the general adoption of the practice is apparently the cost of the spraying machine. This year, in order to get over this difficulty, we arranged to send out 12 expert sprayers with machines to spray the crops of those cultivators who wished to have it done. It was expected that each machine would deal with about 20 acres of potatoes, but owing to a long drought in the spring the season proved to be a very bad one



for the potato crop, and consequently the majority of the cultivators were unwilling to bear the cost of spraying on crops which to all appearances were already doomed to failure. Consequently only 32 acres were sprayed, and of this area it is reported that on only 9 acres spraying was successful, the crops on the remaining area being too badly affected by the drought to benefit by spraying.

In an average season the profits due to spraying are usually well over 100 per cent. on the expenditure, which is about Rs. 12 to Rs. 13 per acre including cost of materials and labour.

Next year it is proposed to repeat this demonstration when, if the season is favourable, the machines should be fully employed.

5. During the year two demonstrators were sent out to instruct owners of orchards in the art of grafting. They visited numerous villages in the Khasi and Jaintia Hills and made 333 grafts, 138 of which were pears, 4 apples, 93 peaches, 40 oranges, 31 plums and 27 apricots.

6. In connection with the denudation of the gorges on the southern side of the Khasi and Jaintia Hills caused by excessive "jhuming" of the higher slopes, a site was selected near Maolot village and laid out in terraces with the object of inducing the cultivators to abandon "jhuming" and take up this style of cultivation instead. The area terraced is about half an acre. The crops sown are *rairuk* (a millet), maize and sweet potatoes. It remains to be seen whether this method of cultivation will be successful.

A. G. BIRT,

*Deputy Director of Agriculture, Assam.*

15th September 1913. }

## INTRODUCTION

Land crabs though distributed all over the World seem to have been the subject of very few investigations as is evident from the meagre stock of information available on the subject. Most of the literature written so far deals only with systematic work, the study of the life-history and habits being almost entirely neglected. The present occasion for study arose out of a demand from the cultivators of the Konkan and Sind for remedies against land crabs, which are exceedingly harmful to the rice crop in their areas. The present Bulletin is the result of two years intensive study of the life-history and habits of the crabs commonly found in the Konkan area.

The work was conducted at Karjat near Bombay and though the paper has been entitled "Land Crabs as Agricultural Pests in Western India" most of the experiments were carried on with the two species occurring there in large numbers. These are *Gecarcinucus* (*Gecarcinucus*) *Jacquemontii* and *Paratelphusa* (*Barytelphusa*) *guerini*. These are in fact the predominant species in the area in question but a few data with regard to the other species which have been found have also been included.

No attempt has been made at systematic description. The scientific determination of the different species was very kindly made by the Authorities of the Indian Museum, and the description given in the text has been taken from Alcock's Catalogue of the Indian Decapod Crustacea.

The main purpose of the present Bulletin is, however, to place on record an account of the details regarding the life-history and habits of the species of land crab which are agriculturally injurious and destructive in the region of the Western Ghats in the Bombay Presidency.

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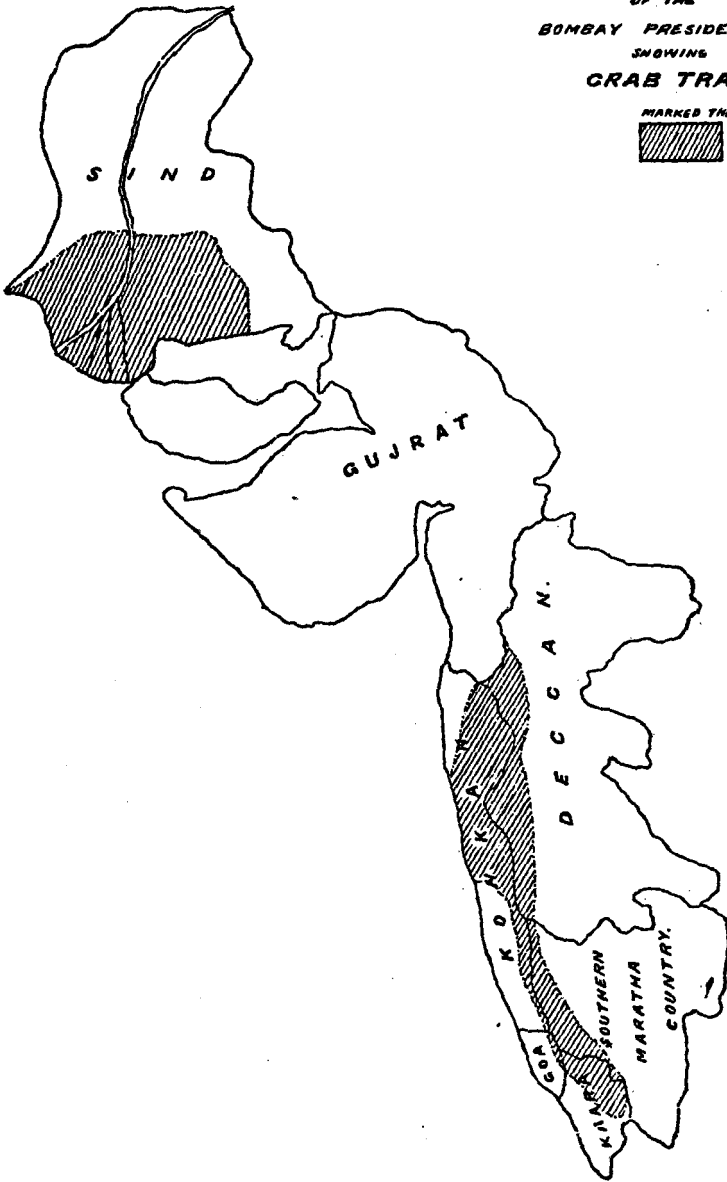
- I. Crabs and their distribution.
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MAP  
OF THE  
BOMBAY PRESIDENCY  
SHOWING  
CRAB TRACTS.

MARKED TRACTS



# LAND CRABS AS AGRICULTURAL PESTS IN WESTERN INDIA.

## I. Land Crabs and their Distribution.

It is only in recent years that the land crab has been attracting any considerable attention as one of the serious agricultural pests. In spite of the fact that crabs have been known as serious agricultural difficulties for many years, few attempts have been made to study the life and habits of these animals or to find out effective measures of control. This is probably due to the strange subterranean mode of life that the animal leads, making the problem a very complicated one. But the loss that this small creature causes every year not only in India, but also in other countries, is so large that it was thought worthwhile to undertake the study of the problem in one particular area in Western India. The present paper is the outcome of two years' work carried on in connection with this pest.

Land crabs are distributed very widely all over the world. They have been recorded from India, Ceylon, South Europe, North Africa, Baluchistan, Afghanistan, the islands of Malaysia, the Malay Peninsula, China, Japan, New Guinea and many other centres. In the Indian Empire they are to be found in the North West Frontier Province, the Punjab, the Western Himalayan territory extending as far as Nepal, the Eastern Himalayan territory including Sikkim, Bhutan, and the lower Brahmaputra drainage system, Burma, Malaya territory, the Indian Peninsula, south of the Indo Gangetic Plain, and the Indo Gangetic Plain itself. \*

In Western India, the parts infested are South Sind, the Thana and the Kolabā District, the Northern and Eastern parts of the Ratnagiri district in the Konkan, and the parts of the country immediately to the east of the Sayhadri range in the Deccan and Karnatak. It will be seen from this that crabs can exist under very varying climatic conditions, from the hot rainless arid tracts of Sind to the heavy rainfall tracts of the Konkan. It will also be noticed that the areas infested are mostly rice tracts, whether the rice is grown with monsoon water or under irrigation. The fact that rice areas are those chiefly infested is also brought out

\* Catalogue of the Indian Decapod Crustacea in the Collection in the Indian Museum, Part I, Brachyura by A. Alcock, pages 7 to 9.

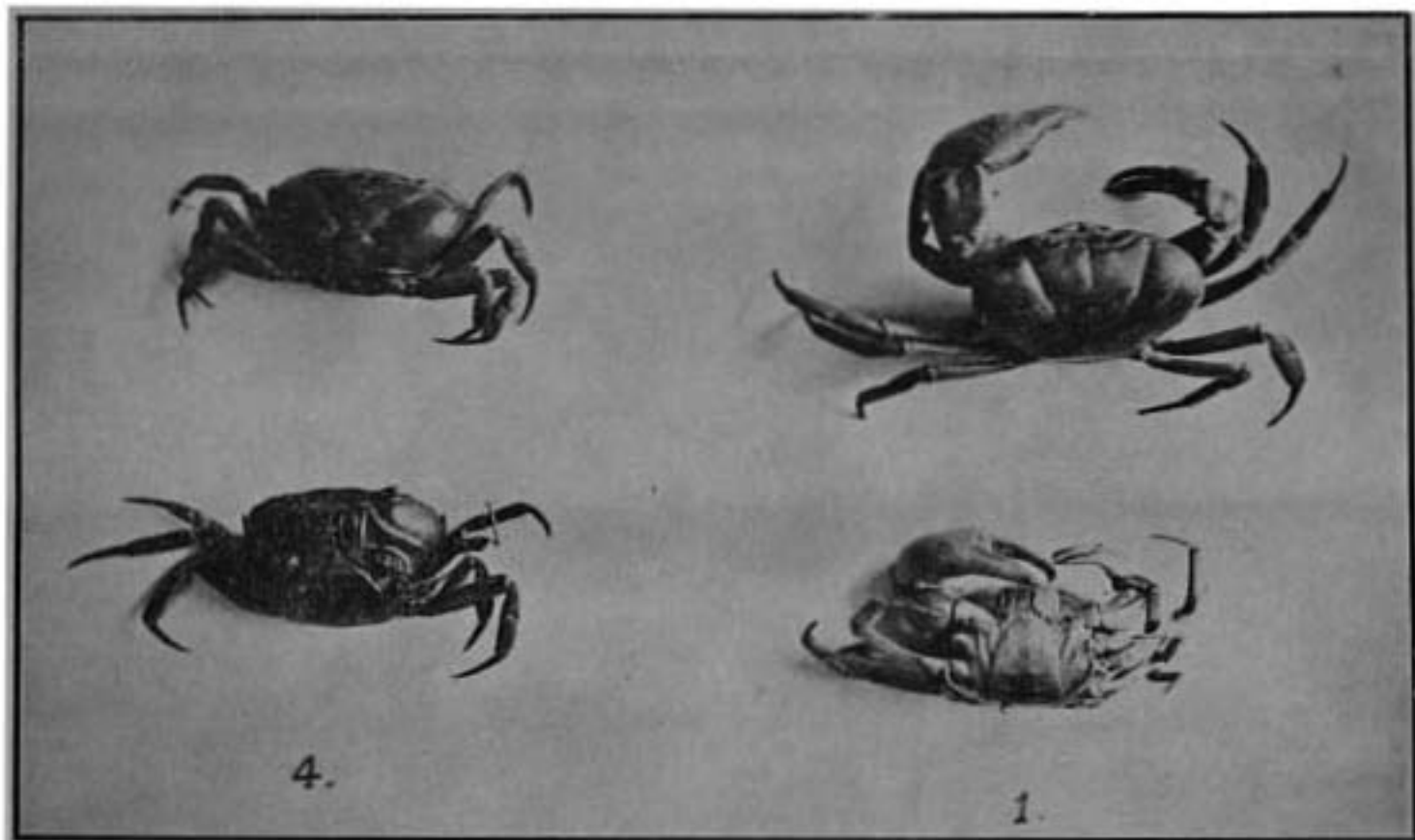
by the study of the crab regions of the world. A study of the soils of some of these places shows that a stiff compact soil, either derived from trap or of an alluvial nature capable of retaining large quantities of moisture is very congenial to their life. Sandy soils or loose soils of other types, such as those derived from laterite on the coasts of the Kanara and Ratnagiri Districts, are almost free from these pests, while in the transition tracts from trap to laterite soils in the northern part of the Ratnagiri district, they are present only to a small extent. They are found at all elevations from the sea coast to a height of 2,000 feet from the sea level in the latitude of Bombay. The following table gives the soil and climatic conditions of typical crab and non-crab tracts of Western India :—

Serial No.	Name of the place.	Nature and origin of the soil.	Rainfall, inches.	Temperature.	
				Maximum.	Minimum.
<i>Crab Tracts.</i>					
1	Karjat ...	Trap ; clay soil ...	125.0	...	...
2	Lonavla ...	Do. ...	180.0	...	...
3	Alibag ...	Trap ; brown clay ...	81.5	90°F	57°F
4	Mugad near Dharwar.	Alluvium from Shale ...	about	...	...
5	Larkhana, Sind ...	Alluvial stiff clay ...	5.3	124°F	30°F
6	Mirpur Bathoro, Sind.	Do. ...	3.2	...	...
7	Belgaum ...	Trap ; brown clay ...	52.0	...	...
<i>Non-Crab Tracts.</i>					
1	Kumta ...	Laterite ; grey soil ...	142.0	93.4°F	61.5°F
2	Ratnagiri ...	Laterite ; gravelly to loamy soil.	96.7	91.3°F	66.6°F

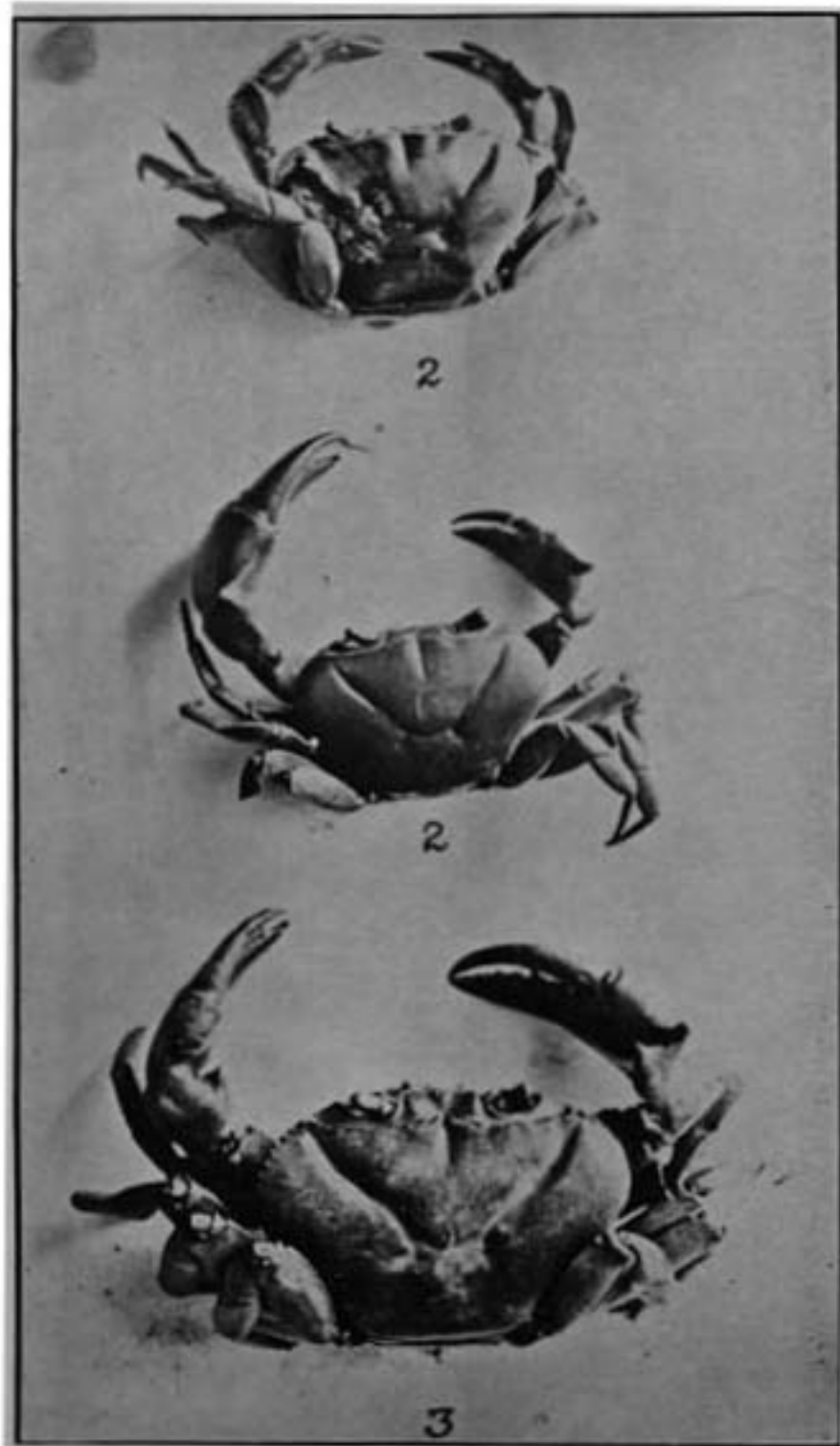
Besides these, there are in some parts of Western India, along the sea coast, or sometimes even in land by the side of creeks, salt lands which are able to grow coarse varieties of rice. These salt rice lands are not free from the troubles of the land crab, but no special investigation has been made in connection with them.

## II. Species of Land Crabs in Western India.

There are to be found in India a number of species of land crabs which have been variously classified by different authors. We have, however, followed Alcock, who has classified them under the three important genera, *Potamon*, *Paratelpusa*, and *Gecarcinucus* of the family *Potamonidae*.

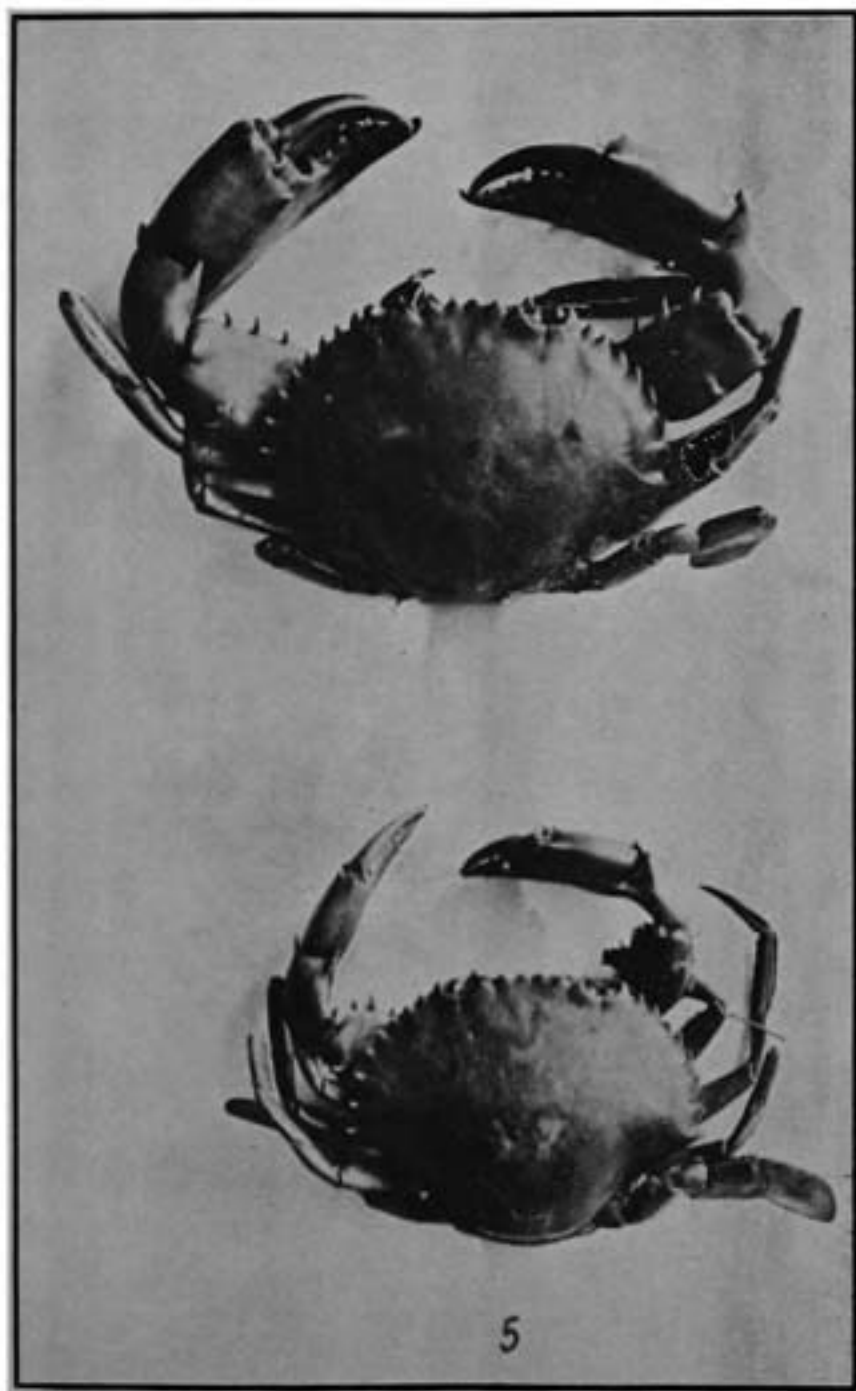


4. *Paratelphusa* (*Paratelphusa*) *spinigera*, Wood—Mason.  
1. *Gecarcinucus* (*Gecarcinucus*) *jacquemontii*, Edwards.



2. *Paratelphusa* (*Barytelphusa*) *guerini*, Milne Edwards.  
3. *Paratelphusa* (*Barytelphusa*) *jacquemontii*, Rathbrin.





5. Salt Land Crab.

Strangely enough, Western India, unlike all other parts of India, has the first genus, *viz.*, *Potamon* almost absent from it, while the third genus, *viz.*, *Gecarcinucus* is restricted to it. Thus the present paper deals only with species coming under the genera *Paraielphusa* and *Gecarcinucus*.

The following are the important species which we have found as agricultural pests :—

(1) *Gecarcinucus (Gecarcinucus) jacquemontii* (*Milne Edwards*).—This is distributed over the Thana and Kolaba districts and also over the tracts of the Deccan immediately to the east of the Sayhadri range. These are the only parts of India where this species occurs. It is locally known as *Muthya*, from its resemblance of the fist. The colour varies from light to dark brown. Alcock's description is as follows:—

“Carapace convex, subcylindrical, its depth considerably over half its length, broadly oval, its length hardly two-thirds its greatest breadth, its surface and side walls practically smooth to the naked eye.

‘Cervical’ groove very broad and deep, running in a long narrow, markedly antero-posterior loop.

Regions of carapace very clearly defined, individually tumid, post-frontal mesogastric groove long, a distinct tumid oval facet in the cardiac corner of either epibranchial region and between them two smaller, less distinct praecardiac facets.

Front, in the adult a long narrow square cut vertically deflexed lobe, not or hardly wider than the orbit, broadly bilobed in a dorsal view, and with a somewhat bilobed surface owing to the faint anterior prolongation of the mesogastric groove.

As the anterior part of the carapace is deflexed very little is seen of the orbits in a dorsal view, they are wide, and have a thick smooth lip-like margin, which is broken only by the wide antennal gap, their lower border is so bent as to form a large right in the orbital cavity at its lower corner, the external orbital angle is quite suppressed.

Antero-lateral borders of carapace strongly arched, longer than the postero-lateral, with a tumid margin, which, however in its front part is defined by

a low, thick obscurely crenulate edge. There is no trace of an epibranchial tooth, the sweep of the antero-lateral margin being hardly broken where the cervical groove meets it.

Epigastric crests low, blunt, obscure, continuous on either side of the mesogastric groove with the still blunter and more obscure post-orbital crests, the latter are approximated to the orbit and follow its curve, but can seldom be traced beyond the cervical groove.

Abdomen of adult male fairly regularly and narrowly triangular, in the 6th segment the sides converge, and the length exceeds the distal breadth, the 7th segment is tongue-shaped, and its maximum breadth is not two-thirds its length. Abdomen of adult female comparatively narrow, the length of the 7th segment being equal to its proximal breadth.

Antennal flagellum short.

The edge of the epistome is deeply trilobed (as is common in *Potamonidae*) but the outer lobes are everted so that the excurrent branchial opening is subtubular.

Mandibular palps as described in the diagnosis of the genus.

The exopodites of all the maxillipeds have a strong plumose flagellum. In the external maxillipeds the exopodite is longer than the ischium, the ischium is longitudinally grooved, and the merus is sub-quadrangular and broader than long, these appendages do not shut close against the epistome, so that the channelled plate of the endopodite of the 1st maxillipeds is more exposed than it is in most other *Potamonidae*.

Chelipeds markedly unequal in both sexes, but most so in the adult male. All three borders of the merus, the inner border of the carpus and the upper and lower borders of the palm are usually crenate or crenulate. The surface of the merus is faintly rugulose, that of the carpus is nearly smooth to the naked eye, except for pitting, that of the hand and fingers is coarsely pitted. Inner angle of carpus spiniform. In the smaller cheliped the dactylus

is much longer than the palm, the fingers are broad, and gape little or not at all, at base, the teeth of the proximal half are lacinate, but none of them is much enlarged, and the teeth of the distal half are small, translucent, incisor-like, and very close-set and regular. In the larger cheliped also the dactylus is much longer than the palm, the fingers are compressed, and are very broad and strong, and gape at base when closed, the teeth of the proximal half are lacinate and about two of them are very much enlarged and the teeth of the distal half are small, translucent, incisor-like and are very close and regularly set in a straight row.

Legs stout, about as long as the smaller cheliped, dactyli slender, and a good deal longer than the propodites, longer propodites hardly twice as long as broad.

In a large male the carapace is  $1 \frac{5}{16}$  inch long, 2 inches broad, and  $\frac{7}{8}$  inch deep."

(2) *Paratelphusa (Barytelphusa) guerini* (Milne Edwards).—This species is to be found in the Thana and Kolaba Districts and in the Deccan. It also exists in other parts of India. It is of various colours, dark-brownish with yellowish border, whitish, &c. The dark brownish are invariably females, the whitish are invariably males, while those intermediate in colour are both males and females. The eye stalks are very prominent, white in colour with black tip. The female has a very broad abdomen. Its local name is "*Khekada*."

Alcock's description is as follows:—

"Carapace broad, deepish, and strongly convex its length in the adult male is about two-thirds its greatest breadth, but is more than two-thirds in the adult female, its depth is half its length or more, its surface is to the naked eye smooth, except for a few short faintish rugae just inside the lateral borders.

Cervical groove broad and deep running towards but not reaching the site of the lateral epibranchial tooth.

Except for the longitudinal mesogastric furrow the regions of the carapace are not areolated.

Front in adults, more than a fourth the greatest breadth of the carapace much deflexed, rather square cut, although its sides are convergent, and its smooth edge is feebly bilobed, its surface, though smooth is tumid.

Orbits, with a smooth edge, the outer orbital angle is very broad, low and blunt, and there is no distinct gap ventral of it.

Antero-lateral borders of carapace strongly convex, well defined, bluntly and rather irregularly crenulate, the lateral epibranchial tooth and notch are only just discernible at the best of times.

The epigastric and post-orbital crests form one bold ridge on either side of the mesogastric furrow the epigastric portion being distinguished by its bluntness and greater thickness, the crest ends on the dorsum of the carapace *well behind the site of the lateral epibranchial tooth*, and it is not anywhere cut by the cervical groove.

In the male abdomen the 6th segment is long (its length almost equal to its greatest breadth), but the sides are distinctly convergent, the blunt 7th segment is longer than broad.

The mouth parts are as described in *jacquemontii*, the only noteworthy difference is that the merus of the external maxillipeds is, as in *cunicularis*, more quadrangular in outline.

Chelipeds much more unequal in the male than they are in the female much as described in *jacquemontii* with the modifications noticed in *cunicularis*, that is to say, the fingers particularly the fixed finger are broader, and none of the teeth is remarkably enlarged.

*Legs as described in jacquemontii.*—In an adult male the carapace is  $1 \frac{6}{16}$  inch long and  $11/16$ ths inch deep."

(3) *Paratelphusa (Barytelphusa) jacquemontii (Rathb)*.—This is one of the biggest and the flattest species, and is the commonest Indian type. Like the previous one, it is found in the Thana and Kolaba districts and the Deccan in the Bombay Presidency. Its general colour is dark brown. The ventral side and

the cervical groove have a slightly yellowish tinge. The abdomen of the female is broad. The animal has a formidable look. It is locally known as "*Chimhuri*."

Alcock's description is as follows:—

"Carapace flat, though the three main regions have a certain individual convexity, its length three-fourths its greatest breadth in adult males, but more than three-fourths in adult females, its depth a good deal less than half its length, the lateral half of each epibranchial region is traversed by many fine oblique ridges which become a good deal effaced in very large specimens.

Cervical groove very bold and deep in all its course, broadly V shaped running to the lateral epibranchial tooth on either side. Regions of carapace not areolated. Mesogastric furrow deep.

Front in large adults a fourth the greatest breadth of the carapace, somewhat more in smaller adults, little deflexed, its sides convergent, its edge faintly bilobed and almost smooth, its surface pitted and rough, except near the orbital margin.

Orbits wide, their inner gap also wide, external orbital tooth distinct, with at most only a trace of a gap between it and the lower orbital margin.

Antero-lateral margins of carapace well defined, sharpish, but hardly crest-like, rather irregularly crenate, arched, lateral epibranchial tooth well formed sharp.

The epigastric and post orbital crests form one bold much undermined ridge sweeping on either side with a slight anterior concavity from the mesogastric furrow to the lateral epibranchial tooth, but separated from that tooth by the deep cervical groove, the epigastric portion of each crest is distinguished by a double or eroded edge.

In the abdomen of the adult male the length of the 6th segment is equal to its greatest breadth, the segment being squarish with the sides slightly concave, the length of the 7th segment exceeds its greatest breadth.

Mandibular palp as in the type of the genus *P. tridentata* Edw., the 1st and 2nd joints being

fused together and the terminal joint being bilobed from the base, the broad anterior lobe overhanging the ventral surface of the mandible, and the falciform posterior lobe lying behind the incisor process of the mandible.

In the external maxillipeds, the exopodite is much longer than the ischium and carries the usual strong, plumose flagellum, the ischium is longitudinally grooved and the merus is broader than long and has an oblique anterior border.

The chelipeds are not very unequal in the female, but are considerably unequal in the adult male, in the merus the edges are crenulate and the outer surface is transversely rugose, in the carpus the upper and outer surfaces are rugulose, and the inner angle forms a strong coarse spine, the palm and fingers are pitted, the pits especially on the fingers having a linear arrangement and there are some squamiform tubercles on the upper surface of the palm, the tips of the fingers are hooked and the fixed finger is much broader than the dactylus. In the smaller cheliped the fingers are a good deal longer than the palm, do not gape much when closed and have fairly even teeth, one tooth in the fixed finger being a little enlarged. In the larger cheliped the fingers are as long as or very slightly longer than the palm, both of them have near the base one tooth greatly enlarged and the dactylus is considerably arched, so that the fingers gape a good deal when the tips are opposed, this being most marked in old males.

The legs are very strong but are shorter than the chelipeds, the longer propodites are about twice as long as broad, and are not much shorter than their dactyli in the old males.

This species attains a large size, in the largest male the carapace is 3 inches long and 4 inches broad, and the hand (fingers included) of the larger cheliped is 4 inches, the palm being 2 inches long just under 2 inches high and more than an inch thick."

(4) *Paratelphusa (Paratelphusa) spinigera*.—This species is restricted to Lower Sind, Bengal, and some

other parts of India. It is very much akin to the *Paratelphusa hydrodromus* of the Madras Presidency. It is greenish brown in colour and is known as *Sianto*.

Alcock describes it as follows :—

“Carapace broad, convex, its length about two-thirds its greatest breadth, its depth about half its length, its surface except for some very fine ripples at the postero-lateral borders is smooth and sometimes almost polished.

“Cervical” groove deep, running towards the outer ends of the postorbital crests, but becoming superficial and quite indistinct just behind them.

All the regions are distinct and individually tumid. A dimpled oval facet is marked off in the gastro-cardiac angle of either epibranchial region, and between them are two small somewhat sunken oval praecardiac facets. The post-frontal mesogastric groove is well marked.

Front in the adult about one-third the greatest breadth of the carapace, its sides strongly convergent, it is little declivous up to its sharp free edge, which is formed more distinctly than usual (as in *P. hydrodromus*) by the knee of the bend that turns in to make the antennular septum and the eave of the antennular fossae.

Orbits small, with a very wide antennal gap. External orbital angle broad, prominent beyond and discontinuous with the lower border of the orbit but not separated from the latter by a distinct notch.

Antero-lateral borders of carapace well arched, longer than the postero-lateral, sharp, indistinctly crenulate or almost entire, the acute prominent epibranchial spine is placed very far back.

Epigastric crests prominent with the anterior surface rugose, overlapping and slightly in advance of the post-orbital crests, the latter are thin, trenchant, and sinuous, and gradually become indistinct beyond the point where the cervical groove approaches them.



Abdomen of adult male a broad-based triangle in outline, 6th segment with concave sides, its length exceeds its distal and equals its proximal breadth, 7th segment longer than broad, broadly rounded anteriorly.

Mandibular palp as described in the diagnosis of the genus.

Exopodites of all the maxillipeds with a strong plumose flagellum. In the external maxillipeds, the exopodite is longer than the ischium, the ischium is longitudinally grooved near the inner edge and the merus is a lot broader than long and has an oblique anterior edge.

Chelipeds very unequal in both sexes, longer in the male than in the female, their surface to the naked eye is smooth, sometimes almost polished. The spine near the end of the upper border of the merus is distinct and usually acute, that at the inner angle of the carpus is strong, the fingers are moderately broad, they are strong and sharp pointed and their tips are inclined to cross, the dactylus is longer than the palm. In the smaller cheliped the fingers are not much bent and so do not gape much when closed, one tooth in the fixed finger may be enlarged but there is no very marked inequality in the teeth of the dactylus. In the larger cheliped the dactylus (especially of the male) is much bent, and there is a large molar near its base and usually a second enlarged tooth beyond its middle, while in the fixed finger there is a very much enlarged molar or double tooth not far from the base.

Legs stout, not as long as the chelipeds in either sex, dactyli strong, longer than the propodites, the longer propodites are about thrice as long as broad.

In a large male the carapace is  $1 \frac{7}{8}$  inches long,  $2 \frac{7}{16}$  inches broad and 1 inch deep, and the larger hand (fingers included) is  $2 \frac{7}{8}$  inches long, the extreme length of the dactylus being 2 inches. In a large female the carapace is  $1 \frac{3}{4}$  inch long  $2 \frac{3}{8}$  inches broad, and 1 inch deep, and the larger hand is  $1 \frac{7}{8}$  inch long, the extreme length of the dactylus being  $1 \frac{1}{4}$  inch."

### III. Life History and Habits of Land Crabs.

As has been already stated the complete life history of the land crab is still not completely understood. The semi aquatic life, the nocturnal and subterranean habit, the comparatively short period of active life near the surface of the ground and the long period of hibernation of the creature are some of the difficulties that the study of the life history of the land crab is beset with. Attempts made in this direction during two years throw considerable light on several points and the present is an effort to put together in a concise form the information that has so far become available under the following different heads:—

#### (a) *Conditions favourable for Crab Infestation.*—

Under the study of distribution it was seen that all localities are not suited to the habitation of the crab. It was also seen that sticky or heavy soils are congenial, while sandy soils are not. Sticky soils are retentive of the large quantities of moisture which is necessary to the crab for respiration, and for keeping down the temperature, to the extremes of which it is very susceptible. The depth of the water level in the land in the hot weather does not sink very low (beyond ten to fifteen feet) in the sticky soils where they occur, as it does in the sandy soils. The relation of the crab to the depth of the water level will be seen later on. Crabs live inside burrows. If the soil in which the burrow is dug is sticky, the burrow excavated remains quite intact. If on the other hand it is excavated in sandy soil it will very soon collapse and the crab inside will find a ready grave in the substratum. Besides there should be no rock or any other hard layer underlying the soil for the crab cannot burrow through rock or even through very hard layers of soil. From this it is clear that crabs are only likely to be prevalent in tracts with sticky soils, with a large water supply at least during part of the year from rain or from canals, and without any hard rocks in the immediate substratum. All these conditions are to be met with in the rice growing tracts which have been described as their most common habitation.

#### (b) *The Location of the different species of Crabs in the Fields.*— The different species of land crabs which we have studied differ from each other in their water requirements, and accordingly they seek different

positions in the field. The species *Gecarcinus* (*Gecarcinus*) *jacquemontii* and *Paratelphusa* (*Barytelphusa*) *guerini*, excavate their burrows mostly in the *bunds* (embankments) between the rice fields, and also in various parts of the rice fields standing above the water level. The following appear to be some of the reasons why the bunds are more suited for their habitation:—

(1) These crabs badly require oxygen from the air. In the rainy season when the fields are flooded with deep water they find it hard to rise to the surface as they cannot swim. So they take shelter in *bunds* and other high lying places which stand above the water level.

(2) The field surface is often disturbed by operations like ploughing, burning of *rab*, puddling, transplanting, &c., almost all the year round. The bunds are comparatively safe and hence they choose these places.

(3) The bunds are places growing grass and other green vegetation which affords food material to the crabs during a greater part of the year than the fields themselves.

(4) The bunds are usually softer for digging than the fields themselves.

These species inhabit also uncultivated *mal* (high lying) lands provided the water level in them does not lie very low. They are, however, absent from the hills or the slopes where the hard rocky substratum and the difficulty of water come in their way.

The species *Paratelphusa* (*Barytelphusa*) *jacquemontii* is not so commonly found in the rice fields as the other species named. It is mostly found along the banks of hillstreams and in fields situated at the foot of hills. In other fields it is found in places having constantly flowing water. In fact it seems to prefer the banks of running streams.

The species *Paratelphusa* (*Paratelphusa*) *spinigera* and *Paratelphusa* (*Barytelphusa*) *cunicularis* are said to occur both in the bunds as well as in the fields themselves and are distributed equally all over. Fields lying near reservoirs of water, however, contain a greater

number of them, and are more affected by them as agricultural pests.

(c) *When the Crabs move out from their Burrows.*—Most of the species of land crabs we have studied are nocturnal in their habits, that is to say as a rule they do not come out by day. During the day time they remain inside their burrows and feed on the material taken in and stored at night, coming at the most to the opening of the burrow and moving out occasionally in the early mornings or late in the evening. The *Paratelphusa* (*Barytelphusa*) *cunicularis* forms an exception to this, for it is said to come out freely even by day. Circumstances can, however, bring about a change in this habit of movement of the crab. For example *Gecarcinucus* (*Gecarcinucus*) *jacquemontii* and *Paratelphusa* (*Barytelphusa*) *guerini* can hardly be seen by day outside in the fields at Karjat lying at the foot of the Western Ghats, while at Lonavla just on the top of the Ghats, these very species can be seen in large numbers on *mal* lands and fields even at midday. The cause is not far to seek. On account of the heavy precipitation in the Ghats all the fine material in the upper layers of the soil has been washed away, and the soil thus impoverished does not grow rank grass on the *bunds* and *mal* lands. Unable to collect sufficient from the small grass to satisfy their hunger during the night the crabs are compelled to come out frequently by day and carry morsels of grass from time to time.

(d) *Seasons of Activity and Breeding.*—The season of activity of land crabs begins just after the first showers in June and lasts till October or part of November. In June the crabs crawl out in numbers from their deep summer haunts. From careful observation of a number of burrows it has been noticed that the crabs from open burrows (it is to be understood that some burrows are open and some are closed as will be seen later), are the first to come out after the first monsoon showers are received. It seems to be the spattering sound of the rain that serves to the crabs as an indication of the advent of the monsoon, for there was neither thundering nor lightning on the days when the observations were made. Even the moisture had not soaked beyond a depth of four or five inches to make the crabs

feel the change in the environment. The crabs inside the closed burrows on the other hand come up one by one within the space of a month. The openings of these burrows being quite closed, the crabs inside were as it were cut off from the outside world and they only became cognisant of the favourable condition when the rainwater actually soaked to their depth. In support of this it might be pointed out that the crabs can be attracted to the surface even during the hot weather by producing a sound similar to the spattering sound of the rain\*. Similarly artificial irrigation until the soil is completely saturated with moisture induces them to come up. In Lower Sind there is the practice of ploughing and irrigating some parts of the rice fields in April for turning them into seed beds. In these the crabs do come up to the surface while there is no sign of any change in the neighbouring unirrigated fields.

This sudden appearance of the crabs in June leads many people to think that they are brought along with the streams like the fish. But they are not migratory, their only movements being from one stratum of the soil to the other in the same field. When adult females of the various species of *Paratelphusa* come up they bring with them small young ones in their abdominal folds attached to the leaf like appendages (*viz. pleopoda*) and liberate them in shallow water in the field. Each female carries from two to three hundred young ones, or sometimes even more. They measure from 0.25 to 0.3 c. m. in length and 0.3 to 0.4 c. m. in breadth, when liberated. Unlike these species, the *Gecarcinucus* appears to liberate them deep down into the burrow, probably in the month of March or April. On several occasions these young ones were come across in the burrows of crabs that were dug. In each burrow they were about one hundred in number, but of the same size as those liberated by the *Paratelphusa*. When the burrows are full of water in June the young ones float up to the surface and can be seen coming up in numbers to the mouths of the burrows. These observations coupled with the fact that no adult female carrying young ones was ever come across, led to the conclusion that the females of the *Gecarcinucus* do not carry their young ones with them but liberate them in the burrow.

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\* Proceedings of the Third Entomological Meeting, Pusa, Vol. II, page 688 (1920).

Land crabs breed only once a year. It is not known exactly when the mating takes place. A number of pairs were kept under close observations, but we have only been able to notice actual copulation on two occasions, once in the field and once in the laboratory. In the middle of July one evening at about 7 p. m. two crabs (*Gecarcinucus*) a male and a female were found resting together in a small burrow with their ventral surfaces in contact. Again in the first week of December about 3 p. m. two crabs (*Gecarcinucus*) of opposite sex that happened by chance to be kept in one jar were actually seen to copulate. The sizes were:—*male*, length 3.1 c. m., breadth 4.3 c. m., *female*, length 2.9 c. m., breadth 4.0 c. m., the male being bigger than the female. This shows that crabs of this size may be taken to be adult and that the mating may take place some time before they go into hibernation. In two or three cases it so happened that the males were fed upon by the females thus giving some room for suspicion that the females might sometimes be eating the males after copulation. From the fact that the female crabs are able to live even after reproduction and show signs of development of eggs in their ovary, and also that much bigger specimens than the above ones of breedable age have been frequently collected, it appears that crabs may produce young more than once in their life-time. That the growth of crabs does not stop at maturity, as in insects, has also been observed by Rao Sahab Ramachandrarao of Madras.\*

(e) *Burrows*.—Land crabs live inside burrows in the soil. This affords them shelter from the enemies and from the extremes of temperature. But more important than this is the necessity of water supply which is to be found at the bottom of most of the burrows. We have seen how the females of the *Gecarcinucus* liberate their young ones in their burrows. These remain inside their mothers' burrows for about a fortnight or so and then begin to excavate small independent burrows of their own. The young ones of *Paratelphusa guerini*, on the other hand, being liberated by their mothers in the fields remain there and imitate the colour of the soil. When alarmed they seek shelter under loose soil, moss, stones and such other things.

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\* Paper read at the fifth Entomological Meeting at Pusa by Rao Sahab Y. Ramachandrarao, M.A., F.E.S. and P. Susainathan, F.E.S. (communicated in manuscript by the authors).

After two or three weeks they begin to burrow shallow tunnel shaped burrows under which to hide and finally excavate deep burrows generally along the level of water in the fields. When the water in the fields begins to dry up these crabs begin to excavate burrows in the middle of the field as well.

In order to compare the number of crab holes in the fields and *bunds* in different localities and thus see what positions or localities are more suited to them, counts of the crab burrows in fields and *bunds* were taken in different localities and can be seen from the following table:—

(1) *Counts in Rice Fields.—Kolaba District.*

Locality.	Position of the field.	Area in Sq. Ft.	No. of holes found per 100 Sq. Ft.	Remarks.
1. Ladivali	High lying	8,400	9	
"	"	9,600	8	
"	Neither high nor low lying.	6,500	24	
"	Low lying	3,182	5	
"	High lying	16,368	11	
"	"	6,116	23	Bunds with breaches.
"	"	4,400	7	
2. Karjat	"	18,600	9	
"	"	14,784	5	
"	"	26,216	5	
"	Very high lying; all bunds leaking.	22,302	122	Field surface very irregular, bunds with breaches.
"	Along river bank	13,104	19	
3. Mudri	High lying near hill.	15,800	13	
"	" field level uneven.	11,500	21	
"	High lying	13,580	11	
"	"	10,000	22	
"	High lying near river bank.	15,700	16	
"	"	10,000	12	

Locality.	Position of the field.	Area in Sq. Ft.	No. of holes found per 100 Sq. Ft.	Remarks.
3. Mudri—contd.	High lying field very leaky.	10,440	27	
"	High lying, soil very shallow.	6,240	10	
"	High lying	10,720	4	
"	"	4,692	51	Fields neglected.
"	Rather low on a bank of <i>Nala</i> .	16,500	56	Do.
4. Kiriwali	High lying	6,200	14	
"	"	13,600	30	
"	"	15,000	51	
"	"	12,200	10	
5. Halivli	High lying, near hill.	10,000	18	
"	"	5,270	99	Field without any regular bunds.
"	High lying	10,000	9	
"	"	7,500	32	Field neglected.
"	High lying near hill.	9,200	14	
"	"	6,300	25	Do.
"	Low lying	5,625	21	
"	"	8,230	12	Soil underlaid with rock.
"	"	13,000	24	Field-surface uneven.
"	"	9,000	7	
6. Bhisegaon	High lying at the foot of hill.	4,675	9	
"	"	10,000	23	Do.
"	High lying	8,832	13	
"	"	17,000	2	
"	"	8,000	5	
"	High lying near farm.	3,200	36	Do.
"	"	16,000	6	
"	High lying near hill.	6,000	26	Do.



(2) *Counts in Embankments.—Kolaba District.*

Locality.	Position of the bund.	Area of the bund in Square feet.	Holes found per 1,000 running feet.	Remarks.
1. Ladivali	High lying	500	530	
"	"	400	1,000	
"	Neither high nor low.	195	860	
"	Low lying	148	4,320	
"	High lying	1,240	1,570	
"	"	695	1,840	
"	"	500	2,250	
2. Karjat	"	372	1,370	
"	"	704	1,420	
"	"	1,130	2,160	
"	"	1,593	1,100	Bund very low.
"	Low lying	625	4,410	
3. Mudri	High lying	632	3,160	
"	"	400	2,103	
"	"	140	4,000	
"	"	400	3,300	
"	High lying, near river bank.	500	2,100	
"	"	500	2,700	
"	"	848	2,670	
"	" shallow soil.	156	1,920	
"	High lying, shallow soil.	250	1,000	Bund almost flat.
"	High lying	700	3,510	
4. Kirivali	"	500	3,260	
"	"	500	2,650	
"	"	500	2,120	
"	"	400	4,100	

Locality.	Position of the bund.	Area of the bund in Square feet.	Holes found per 1,000 running feet.	Remarks.
5. Hajivli	High lying, near hill.	400	2,900	
"	High lying	400	3,030	
"	"	500	1,570	
"	High lying, near hill.	400	1,540	
"	" "	270	2,440	
"	Low lying	225	2,330	
"	"	828	1,930	
"	"	300	1,710	
"	"	440	2,100	
"	High lying, near hill.	200	2,800	
"	" "	255	760	
"	" "	400	1,870	
"	" "	404	1,280	
"	High lying	850	2,350	
"	"	300	3,100	
"	"	240	2,440	
"	"	640	3,620	
"	"	320	2,870	
"	"	270	1,550	
"	"	300	1,400	

These figures confirm the idea that *bunds* are better suited for the habitation of the usual crabs near Karjat than the fields. It is also seen that the number of burrows in the fields depends on (a) the condition in which the field is maintained chiefly with regard to the *bunds*, and the level of the land and (b) on the depth and substratum of the soil. With regard to the point (a), when the field has no regular *bunds* or when there are elevated places in the middle of the fields water does not stand on them, and as in the case of the *bunds* the crabs find it very convenient to live. This holds good in all cases whether the field is high or low lying.

With regard to (b), it appears that fields underlaid with rock at very small depths do not present favourable sites to the crabs for burrowing and for hibernation.

The crabs usually provide their burrows with a number of openings probably for escape in times of emergency. This was found out by blowing in smoke through one opening which then escapes through all the other connected ones. From forty trials made in the month of August when the crabs were active, it was found that the number of openings vary from two to twenty-nine, the average number being 10.5. This habit of having a number of openings is particularly to be seen in the case of the *Gecarcinus*, from the young to the adult.

If the openings of a burrow are further traced it is seen that most of them are connected superficially within a foot or two of the soil surface, though ramifications at a depth of four or five feet are not uncommon. A few only go deep down and each one of these deep burrows harbours a crab, probably the off-spring of the same mother liberated in the same burrow, but which has eventually excavated a separate burrow in connection with the mother's burrow.

When the supply of water begins to fail the water level begins to sink, and the crabs also dig themselves deeper and deeper. This can be actually seen from the depths at which they are found during different periods of the year.

No.	Date of digging.	Place.	Depth at which crab was found in water.
1	18-11-1922.	Farm area, Karjat.	5'-3".
2	23-11-1922.	Do.	5'-3".
3	2-12-1922.	Do.	5'
4	11-12-1922.	Do.	6'
5	28-12-1922.	Do.	6'
6	8-2-1923.	Do.	7'

This is also evident from the fresh soil thrown out during periods of drought when the water level falls low.

The work of excavation and carrying up of soil is done by the crabs by means of their powerful pincers. The soil excavated is thrown up in the form of a

**SECTION THROUGH A CRAB-BURROW.**  
 RUNNING NORTH & SOUTH

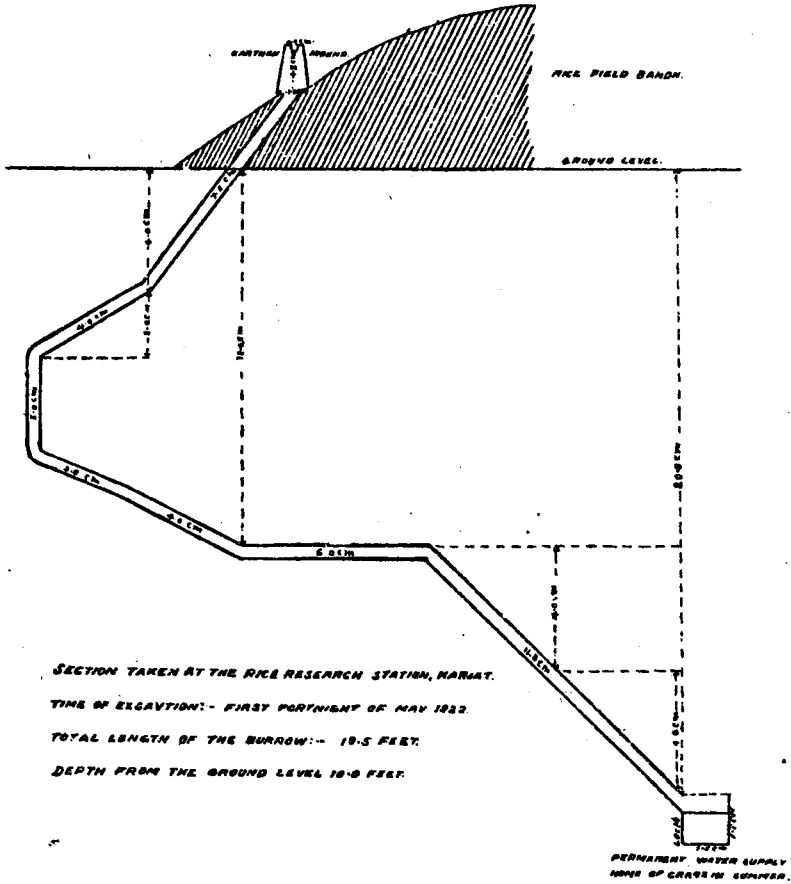
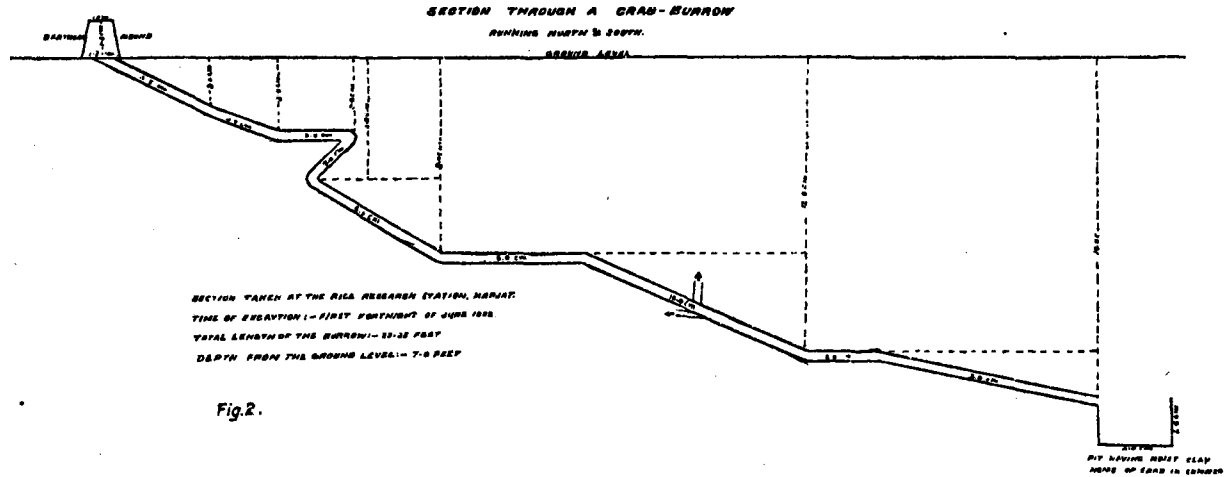
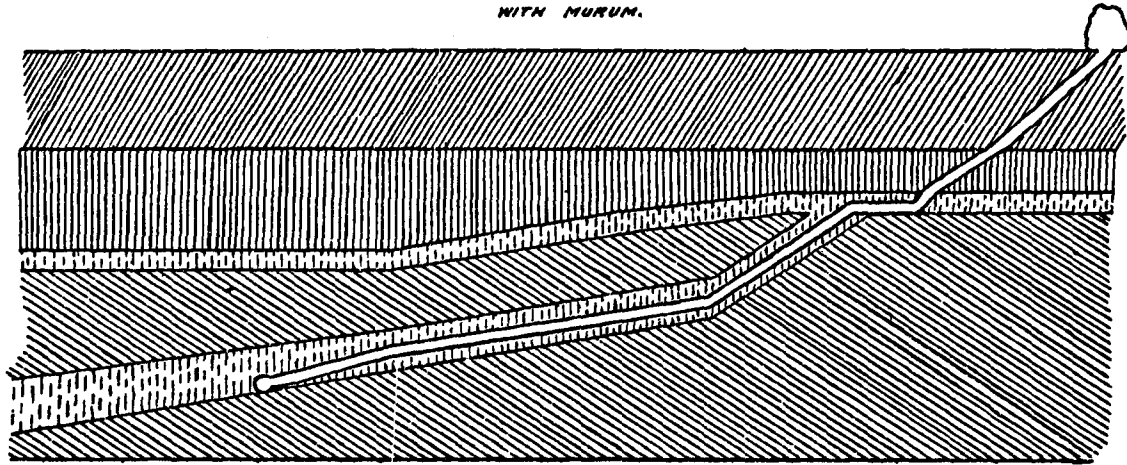






Fig. 1.



SECTION THROUGH A CRAB-BURROW.  
 THE COURSE OF THE BURROW IN A SOIL, UNDERLAID  
 WITH MURUM.



-  SURFACE SOIL.
-  SOFT MURUM.
-  CLAY.
-  HARD MURUM.

scale 1 ft. = 2 cm.

Fig. 3.

mound round about the opening of the burrow. The mound of earth thrown up is very small compared with the depth of the burrow. It appears they remove only as much soil as is absolutely necessary for effecting an entrance, and then try to press the soil against the sides.

The course of the burrow is also another interesting feature. It is not always vertical, as one would expect it to be. It is sometimes vertical, sometimes horizontal, sometimes sloping, sometimes taking a sudden turn at right angles, thus presenting a zig-zag appearance in every possible way (*see* Figures 1 & 2). In Lower Sind, however, the course of the burrows is almost vertical. The course seems to be dependent on two factors, *viz.*, (1) the nature of the substratum and (2) rate of sinking of the water level. When the crab comes across a hard layer of rock or *murum*, it tries to follow a soft layer of soil that generally happens to lie in between two hard layers (Figure 3), and it is the direction of this soft layer that determines the course of the burrow. It is in such cases that the crab sometimes meets only moist clay instead of actual water. That the course is dependent on the rate of sinking of the water level is evident from the facts that the burrows vary in direction even though the substratum is soft, and that they are almost vertical in the irrigated rice tracts of Sind where the water sinks fairly regularly throughout the soil. It has been already said that the crabs go on digging as the water level sinks. If the water level remains in the same stratum for some time owing to intermittent light showers, the crabs will dig in the same plane moving in the direction of greater supply of water, thus giving a horizontal direction to the burrow. If on the other hand the water level falls suddenly on account of a long break in the rains the crab will descend suddenly thus making a vertical burrow; if the water level falls gradually, the crab will also move down slowly moving towards the greater supply of water, and the result is that the burrow has a sloping course. In the irrigated tracts of Sind there is a constant supply of standing water until the crop is harvested when it is suddenly drawn off. So the crabs remain near the surface as long as there is water and then suddenly go down. This sudden downward movement gives a vertical direction to the burrows.

(I) *Foods and Feeding Habits.*—Land crabs in Western India are polyphagous. When they come up in June after a long period of fasting during hibernation they travel long distances in search of green vegetable matter. They readily eat grass and other weeds, rice seedlings, *Bhendi* (*Hibiscus esculentus*), chillies, *til* plants, &c. In fact any green matter that happens to grow at that time is quite welcome to them. They come out at night from their burrows, cut the plants and carry them inside their burrows in sufficient quantity to feed upon even by day. Though known as vegetable feeders they like animal food still more, and eat it with greater relish even than vegetable matter. This was clearly seen in a crab pit especially constructed by lining it on all sides with iron plates to prevent the escape of crabs. Inside the pit were planted rice seedlings to supply them the necessary food material. Insects such as grasshoppers and mutton flesh were fed to the crabs inside the pit and it was found that they preferred the animal to the vegetable matter. Experiments were made by feeding weighed quantities of different materials like grasses, weeds, rice plants, &c., to single crabs kept in cells in water and weighing the material left uneaten after 24 hours. Trials were also made to see whether they would eat more when kept under dark conditions created artificially by wrapping the cells in paper. The results of the experiments are recorded in the following table:—

No.	Food material tried.	Treatment.	Average quantity consumed during 24 hours
1	Rice plants ...	Under dark conditions.	2·7 grms.
2	Do. ...	In open cells...	2·7 grms.
3	<i>Hariali</i> grass ( <i>Cynodon dactylon</i> ).	Do. ...	2·2 grms.
4	<i>Lavala</i> grass ( <i>Cyperus rotundus</i> ).	Do. ...	0·7 grms.
5	<i>Panicum poliferum</i> grass ...	Do. ...	2·3 grms.
6	<i>Euphorbia</i> weed ...	Do. ...	0·3 grms.
7	<i>Ber</i> grass ( <i>Ischaemum aristatum</i> ).	Do. ...	2·2 grms.
8	Half rotten leaves ...	Do. ...	Nil.
9	Dried <i>Kolbi</i> fish ...	Do. ...	0·82 grms.
10	Fresh <i>Kolbi</i> fish ...	Do. ...	2·03 grms.



It is seen that crabs have been equally well off regarding their feeding under dark as well as light conditions. Mixtures of the different plants were also tried and it was found that they like rice plants most of all those used. Then come *Hariali*, *Ber* grass, &c. *Lavala* is not liked and rotten leaves are not eaten at all. Fresh animal matter as said above is liked more than vegetable matter. Besides these, qualitative experiments with rice bran, earthworms, fresh fish, wheat bran, sesamum cake, &c., were made. In these also it was found that earth worms and fresh fish were more readily eaten than the others.

If crabs thus like animal food more than plants, then it appears that they might be more in search of animal matter like fish, earthworms, &c., under the natural field conditions than of vegetable matter. If it were so, the damage to the crop would be very much lessened. But strangely enough, as is seen from the accompanying table, the examination of the stomach contents of crabs collected in the fields revealed in the majority of cases only rice plants, algae and euphorbious weed, and occasionally animal matter.

Species of the crabs examined.	No. of crabs examined.	Crabs having vegetable matter especially rice plants.	Crabs having animal matter.	Crabs with empty stomach or with liquid only.
<i>Gecarcinucus</i> ( <i>Gecarcinucus</i> ) <i>jacquemontii</i> .	38	29	Nil.	9
<i>Paratelphusa</i> ( <i>Barytelphusa</i> ) <i>guerini</i> .	28	16	8	4

All these things go to prove that crabs are naturally carnivorous, but their environment compels them to rest satisfied with vegetable food.

One more very noticeable matter about them is their habit of the cannibalism. This has been specially noticed in the case of the species *Paratelphusa* (*Barytelphusa*) *guerini* at all ages. Though none of the crabs of *gecarcinucus* examined showed any animal matter in the stomach it is not to be inferred that this species is a

vegetable feeder. When two animals or more are put together in one cell they will try to cut each other's legs off, and the stronger will generally kill and devour the weaker one. This habit is, however, less pronounced in the case of the young ones. Crabs have often been found feeding on their own moults.

Comparing the habits of these with the feeding habits of the Madras\* and Burma† species, it can be definitely said that those we have studied do not exhibit that liking for animal food, which is shown by the latter even under field conditions.

(g) *Growth and Life period.*—The young ones liberated in the fields are very small, and vary considerably in their size. As stated already, the sizes vary from 0.23 to 0.3 c.m. in length and 0.3 to 0.4 c.m. in breadth. They feed upon floating leaves in the water. For the first few days they grow rapidly and cast a number of moults, which can be seen in the fields like so many dead crabs. Attempts were made to rear out crabs from young ones by providing soil, water and food in glass cells, and the rate of growth, the moults cast, &c., have been shown in the following table:—

Date on which young ones were kept.	Species of the young crab.	Size of the young when kept.		Treatm. at.	Date on which the crab died.	Size of the crab at the time of death.		Growth made.		No. of moults cast.	Rate of growth per moult cast.		Remarks.
		Length.	Breadth.			Length.	Breadth.	Length.	Breadth.		Length.	Breadth.	
1 4-7-1923...	<i>Gecarcinus</i> ( <i>Gecarcinus</i> ) <i>jacquemoniis</i> .	0.9	1.1	of rice plants	17-10-1923	1.16	1.6	0.5	0.5	2	0.12	0.25	
2 Do. ...	Do. ...	1.05	1.55	of rice plants	27-10-1923	1.2	1.65	0.15	0.3	2	0.07	0.15	
3 Do. ...	Do. ...	0.9	1.2	of rice plants	27-10-1923	1.1	1.5	0.2	0.3	2	0.1	0.15	
4 Do. ...	Do. ...	0.85	1.2	of rice plants	27-10-1923	1.2	1.6	0.35	0.4	2	0.17	0.2	
5 27-7-1923.	<i>Paratelphusa</i> ( <i>Eurytelphusa</i> ) <i>guerinii</i> .	1.0	1.3	of rice plants	23-11-1923	1.8	2.4	0.8	1.1	4	0.2	0.27	
6 Do. ...	Do. ...	1.2	1.5	of rice plants	27-10-1923	1.7	2.35	0.5	0.85	3	0.17	0.28	
7 Do. ...	Do. ...	1.2	1.5	of rice plants	17-10-1923	1.65	2.1	0.45	0.6	2	0.22	0.3	

\* Paper read at the fifth Entomological Meeting at Pussa by Rao Sahet Y. Ramachandrarao, M.A., F.E.S. and P. Susainathan, F.E.S.

† A leaflet on "Crabs in Paddy Field" of the Burma Agricultural Department.

From this table it is evident that the rate of growth of the *Paratelphusa* is greater than that of the *Gecarcinucus*. To compare with this, young ones were also kept only in water and with soil and water without any food. Young ones under both these treatments hardly grew at all and then only during the first few days, being full fed, and about to cast moults before being subjected to the treatment. In order to have an idea of the growth made in the field for comparison with that in the laboratory a number of young ones were collected in the fields every ten or fifteen days and from their measurements striking an average for each species.

The following table shows the average of their growth thus measured:—

Name of the species.	Date of measurement.	Dimensions.	
		Length.	Breadth.
		c.m.	c.m.
1. <i>Gecarcinucus</i> ( <i>Gecarcinucus</i> ) <i>jacquemontii</i> .	3- 8-1922	1.3	1.7
	9- 9-1922	1.5	2.1
	15- 9-1922	1.5	2.2
	6-10-1922	1.5	2.2
2. <i>Paratelphusa</i> ( <i>Barytel-</i> <i>phusa</i> ) <i>Guerini</i> .	3- 8-1922	1.7	2.2
	30- 8-1922	2.1	2.8
	6- 9-1922	2.5	3.4
	15- 9-1922	2.5	3.5
	28- 9-1922	2.7	3.6
	5-10-1922	2.9	3.9
	14-10-1922	2.95	3.95

It was very difficult to collect a large number of young ones of the first species as they go very deep compared with the second. The work had to be stopped when owing to their going deep for hibernation they could not be collected in sufficient numbers. This table though it indicates the relatively faster growth of the second species does at the same time show that under field conditions crabs grow much faster than under our laboratory conditions.

It is very difficult to say how long a crab can live. A young *Gecarcinucus* was reared in the laboratory

in a cell. In one year its length increased by 0.6 c.m. Taking this to be the average yearly growth of an average animal the sizes of crabs of different ages were calculated. In 1923 the sizes of nearly 350 crabs were measured as they came out of hibernation. All these were classified according to the measurements thus obtained allowing for a range of variation of 0.3 c.m. on either side. According to this the crabs could be classified into five classes or the oldest crab came to be of five years. This is, however, an arbitrary method of determining the age, but all the same it gives an idea that the crabs of the *Gecarcinucus* type may normally be living for four or five years.

(h) *Hibernation*.—By the end of October the water in the rice fields begins to dry up and the rice crops also begin to be ready for harvest. When the shortage of water and food and the intensity of heat thus threaten the crabs, they begin to move with the water even at the cost of food, which they could have got from the grass growing on the *bunds*. This shows that water is more important to them than food.

In the beginning we saw how they gradually descend along the water level and in one burrow dug in the month of May a crab was traced at a depth of twelve feet. There is almost always water to be found in the burrows. Occasionally instead of water the crab is found in moist clay containing moisture from 20 to 25 per cent.

Before finally going down into the soil the hibernating crab closes up most of the openings of the burrows. This was found out by pumping in smoke once more. In forty burrows tried at the end of October, it was found that the number of openings varied from two to fifteen, the average number per burrow being 5.1. These readings were taken when the work of closing the openings was still in progress. This shows that nearly half the number of openings of each burrow had been closed up, the average number of openings per burrow in August when the crabs were active being 10.5. The closing is probably done to protect the crab from outside enemies.

The question as to what the crabs feed on during hibernation is often raised. Many people think that

they feed on soil. But the examination of the stomach contents of the crabs that were dug out showed that there was nothing except a small quantity of water which indicates that they do not feed on anything during hibernation, not even soil. To ascertain that they do not come out of their burrows in search of food even at night, all the openings of some of the burrows were traced out and closed. They continued in that condition throughout the hot season. The habits of crabs of remaining without food is very remarkable. Even during the active season a crab kept without food and water was able to live for more than four months. So also crabs have been observed to remain underground for more than a month with all the openings closed in the field. This habit of living without food seems to be a special characteristic of the types of crabs under study, inasmuch as it helps them easily to tide over the hard times during hibernation.

But they have recourse to this fasting only on account of the absence of food material, for whenever it is available they readily feed upon it. Crabs, both young and adults, kept in the laboratory have been seen not only to eat the rice plants fed to them, but even to grow after casting moults. It appears that crabs do not grow during their hibernation and it is probably on account of the short period during the year which is favourable for their growth that the life history of the animal is very long.

During their hibernation the animals are quite sensitive and may be active. If the mound closing the burrow is removed, the crab inside detects it at once, probably by the movement of the air, and closes the opening again with fresh soil brought from below within a few hours. This also shows that the crab closes the openings with a view to segregate itself from the outside world.

The crabs are very hungry after their long fasting during hibernation and come out in large numbers at night in early June.

(i) *Response of Environment—(1) Water.*—From the study of the crab so far made it is clear that water forms the limiting factor in the existence of the crab in the region under study. Wherever there are crabs

there is sure to be water at a limited distance from the surface of the ground. It is said that some people can even locate water from the presence of crabs in a particular place and dig their wells in such places.

Water seems necessary for the species of crabs under study, to keep them cool and also for respiration. In spite of the fact that water plays such an important part in the life of the crab the animal is able to live without water in the shade. A crab kept in a glass jar inside the laboratory without water remained alive for more than three months.

(2) *Sunlight*.—This does not in any way seem to influence their living or feeding (*vide* feeding experiments above). Their habit of remaining inside burrows by day leads one to believe that they are negatively heliotropic. But it appears that they take shelter in the burrows by day only to protect themselves from birds. For it is seen that they are quite active in broad daylight in the laboratory. They were even seen to move out by day at Lonavla where the scarcity of food supply compels them to do so.

(3) *Heat and Light*.—Fires were lit on the *bunds* at night to see if the crabs would be attracted to them, but they were not. Light on the other hand has a dazzling effect on crabs. When a light is suddenly taken before a crab that has come out of the burrow, it so influences the creature that it stands still in its place without trying to escape. This habit can be taken advantage of in catching them at night.

As regards heat, if we go on raising the temperature of water in which a crab is kept, we find that it is quite comfortable up to a temperature of about 100°F, *i. e.*, nearly 38°C. If it is kept in water at a temperature of 100°F to 101°F it dies within about half an hour. At a temperature of 105°F it dies within about 10 minutes, while at 110°F it dies within two or three minutes.

On the other hand if we go on lowering the temperature we find that it is in good condition down to a temperature of about 50°F, that is, 10°C. At 50°F it becomes stiff, benumbed and motionless. In spite of this it is able to withstand this temperature for a fairly long time. For if after keeping the crab at this

temperature for nearly an hour, it is removed, it very shortly regains its former activity. From the above study it is apparent that a crab can withstand lower temperatures much better than higher ones.

This explanation holds good in the case of crabs kept in glass jars in the sun. In this case the crabs die within four or five minutes as the temperature of the inside air rises above 100°F with the heating of the glass jar. The death is apparently not due to strong sunlight.

#### IV. How and to what extent the Crabs are harmful.

The attention of several Indian Entomologists has been of late drawn to the question of land crabs, but none has so far tried to estimate, even approximately, the amount of damage they are responsible for, nor does it appear that the fact that the crabs are harmful to crops other than rice has come to the notice of any of them. As already mentioned the hungry crabs coming up in June readily cut and feed upon any green plants that happen to grow at that time. Among these may be mentioned the vegetable crops like *bhendi*, chillies, French beans, &c., and even *til* (*Sesamum indicum*); plants which are grown either on the *bunds* or on *mal* lands. The destruction of such crops continuously year after year by crabs has driven many a cultivator to despair, some of whom have even given up the cultivation altogether. But considering the acreage under these crops and also under rice, the loss wrought by the creatures to the vegetable crops would fade into insignificance. So, it will be worth while to consider the different kinds of damage to the rice crops only, and the loss incurred by the rice farmer.

The damage done to the rice crop may be briefly described as (1) direct, that is to say, the actual eating of the crop in (a) the seed bed and (b) after transplantation in the field and (2) indirect, that is to say, the effect of a number of breaches in the embankments (*bunds*) in reducing the yield. A third kind of loss which is of still greater importance is the cost of repairs to the *bunds* on account of the habitation of crabs in them. Each one of these causes of loss may be discussed in detail:—

##### (1) Direct Damage to the Rice Crop.

(a) *In the Seed Bed.*—The seed bed in the Karjat area of the Konkan is generally selected in the middle of

the fields, mostly in the high lying area. So the number of crab holes in the seed bed is generally less than in the average field, which has crab burrows mostly situated along the bunds. But, wherever the seed bed area approaches the *bund*, there is invariably found a greater number of burrows. The practice of allowing only shallow water to stand in the seed bed, as is necessary for the seedlings, sometimes invites numbers of crabs from outside. As soon as the seedlings come up, the crabs come out of their burrows at night and nip off the tender seedlings. Thus, there is a circular patch formed around the opening of each burrow. As the animal goes on feeding this patch becomes bigger and bigger day by day. The cut plants throw out new shoots but some of them are again eaten and the rest that grow are so small, compared with the other seedlings, that they are almost useless. By the time the seedlings are ready for transplanting these clear round patches become quite prominent and vary in diameter from one to even three feet. These big patches of three feet diameter were noticed at Lonavla, where, in the absence of any grass growing on the *bunds* the crabs have to maintain themselves only on rice seedlings. It was possible approximately to estimate this damage to the seed bed by counting the number of burrows having patches eaten around them and noting the average diameter of the patches in each bed. Calculating the total area fed upon by crabs, it could be determined how much of the seed bed area was destroyed. The following table gives the figures of damage in some of the villages round about Karjat:—

Serial No.	Name of the Village.	No. of seed beds examined.	Average area of each seed bed.	Average No. of holes of each seed bed.	Average diameter of each patch.	Percentage of damage.		
						Max.	Min.	Ave. rage.
			Sq. ft.		Ft.	Per cent.	Per cent.	Per cent.
1	Bhisegaon ...	10	3,569	10	1.12	0.77	0.061	0.33
2	Halivli ...	10	2,821	14.5	1.37	2.25	0.26	1.01
3	Mudre ...	10	4,174	25.3	1.07	2.3	0.07	0.72
4	Pulachi Vadi ..	10	4,898	19.6	1.15	2.09	0.2	0.70
5	Karjat ...	10	2,702	12.2	0.82	0.50	0.08	0.25
6	Gunagi ...	10	1,762	12.4	0.95	3.68	0.18	0.76
7	Ladivali ...	10	3,461	13.9	1.05	1.13	0.078	0.44
8	Dahivli ...	10	2,448	14.0	1.05	3.2	0.13	0.75
9	Vengsaon ...	10	3,557	11.7	0.9	0.62	0.10	0.24
10	Akurie ...	10	1,990	11.9	0.97	1.02	0.24	0.38
11	Lonavla ...	3	4,061	48.0	2.00			3.7



This damage is thus almost negligible except under certain conditions such as those at Lonavla, where it will have to be considered. Knight reports a damage of 15 per cent. to the rice seed bed at Lonavla,\* but we have not seen such extensive injury.

Most of the cut plants are consumed by the crabs but a certain number of them are left floating about on the water. It appears that these are purposely cut and left about for their young ones to feed on, for some young ones were actually seen to feed on the leaves of these floating seedlings. It is quite probable that the young ones feed only on the leaves, and being unable to reach these on the standing plants, the adults have to cut the plants for the young ones. This cutting of plants and leaving them in the field has led many people to believe that the crabs do not feed on rice plants.† According to T. V. Ramakrishna Ayyar, the soft central pulpy parts of young paddy plants are eaten by the crab *Paratelphusa hydrodromus*, which occurs in Madras. But the crabs in Western India have been noticed to feed on the whole plant. The idea that the crabs do not feed on rice plants formed by several people seems to be based on the idea that the crab as judged from its size requires a large quantity of food material, and that it solely feeds on rice, for it has been said of them that "If the crabs had eaten the plants or had been obliged to cut them in order to get their food, it was clear from the enormously large number present in Barail fields that severe damage would have resulted and probably rice growing would have been impossible"†. But the dissection and the examination of the stomach contents has revealed clearly that the stomach is very small, and the food eaten, as stated before, consists not only of rice plants, but also other grasses as well as animals. Considering the small quantity of daily food, of which rice seedlings form only a part, it is but natural that the damage to the rice crop should be so little. The damage continues until the seedlings are removed from the seed bed.

(b) *After Transplantation in the Field.*— The damage to the transplanted crop begins just after transplanting and continues almost till the crop is harvested though with less severity in the latter part of the season on account of the luxuriant growth of grasses on *bunds*

\* Report of the Lonavla Agricultural Station, 1909-10.

† Proceedings of the 3rd Entomological Meeting, Pusa, page 686 (1920).

which also supply food. This damage is in the form of one or two rows of the crop, all along the *bunds*, which harbour the crabs, but is rarely found, with the species we have investigated, in the middle of the field. Sometimes big patches of clear area are also seen even in the middle of the field in places standing above the level of water. Such places as already stated are well suited for the habitation of crabs and afford shelter to a number of them which in return take their toll on the crop.\*

The plants cut by crabs generally rot. A few of them throw up fresh shoots producing a small earhead. This damage was estimated by counting approximately the number of bunches eaten up by crabs all along the bunds of the field. From the total number of bunches planted in that area the figure of the percentage of damage was worked out. The following table represents the figures of damage in the villages round about Karjat and at Lonavla:—

No.	Locality.	No. of fields examined.	Average percentage of damage.	Remarks.
1	Lonavla	6	10.8	
2	Halipli	10	3.9	
3	Bhisegaon	10	4.6	
4	Gunge	10	8.1	
5	Mudre	10	4.8	
6	Dahivli	10	2.5	
7	Akurle	10	8.0	
8	Ladivli	10	2.2	
9	Pulachi Vadi	10	3.3	
10	Karjat	10	2.9	
11	Vengao	10	2.7	
12	Pali	4	7.1	

Here again the damage is greatest at Lonavla for the reasons stated already.

Different varieties of rice both early and late were included in the above list of fields of the different localities, but no special liking or dislike was exhibited by the crabs for any variety.

### (2) Indirect Damage to the Rice Crop.

Besides the damage described above, there is another kind of damage, *viz.*, the indirect effect of breaches

\* The species *Paratelphusa* (*Paratelphusa*) *spinigera* and *Paratelphusa* (*Barytelphusa*) *cunicularis* are exceptions to this, and damage the crop when there is a large quantity of water standing in the field. The damage considerably diminishes when the water is drained off. But these species do not occur at Karjat, or Lonavla, and our study of them is very small.

produced in *bunds* in reducing the yield. We shall see later on how crabs are connected with these breaches, but suffice it to say here that the crabs are responsible for them. On account of the breaches water immediately begins to leak out of the field. In course of time, the water as it flows widens the breach and a big current is formed, which washes off a large part of the fine material in the soil leaving only the courser particles. Rice is a crop which requires a constant supply of water to stand in the field, and in the absence of water and the fine soil rich in plant food, the crop suffers considerably. Besides, the absence of water encourages weeds which are particularly injurious to the rice crop. We have also seen how such conditions are favourable for the existence of crabs and how it results in the greater damage to the crop. Many of the cultivators do very well know these evil effects of insufficiency of water on the rice crop, but it is only the careful few that try to remedy these evils by effecting temporary repairs to the *bunds* thus preventing the flow of water as far as possible. The difficulty of obtaining labour at a time when people are busy with transplanting operations comes in the way of some of the people. As there is difficulty in obtaining a large quantity of soil during the rainy season when the fields are covered with crops, the repairs are effected by means of twigs of trees and brushes and the large thick coriaceous leaves of certain wild trees which do not rot very easily. In spite of these precautions much water is still able to escape.

During the last season a number of fields with breaches in *bunds* unrepaired were seen in several places. From the standing crop, these when compared with the neighbouring fields, appeared to be from twenty to thirty per cent. inferior in production. Inquiries with the cultivators also proved that there is a reduction in yield to the above extent if the breaches in *bunds* are neglected. But a careful cultivator will never suffer this loss by attending to his fields in time.

### (3) *Damage to the Fields.*

A third kind of loss to the rice farmer is in the form of the cost of repairs to the *bunds*. These repairs every cultivator is obliged to undertake at least once in two or three years, if not every year, to get a crop. We have

seen how the crabs inhabit the field *bunds* (table, page 18) and consequently weaken them with a net work of burrows, which often run across them. During the early rains when the fields are flooded, water begins to ooze out through the burrows from one field to the other especially when the fields are terraced as in the Konkan. This constant oozing out of water from the higher to the lower fields gradually denudes the surrounding soil and thus widens the passage. In the course of a year or two, the current that flows becomes so strong that after a heavy shower, the *bund*, already weakened, collapses and is washed away by the current. This sort of damage is very great in fields situated at the foot of hills, the water flowing down the slopes of which helps the denuding action considerably and the *bunds* are breached almost every year. Similar is the case with the *bunds* in the salt lands near the coast.

In the canal areas of the Deccan, the crabs bore innumerable holes in the water channels, render them hopelessly leaky and are thus responsible for the wastage of very large quantities of irrigation water.

In order to form an idea of the approximate cost of repairs that a cultivator is required to undergo round about Karjat, every year or once in two or three years as the case may be, a number of inquiries were made with the cultivators. The average cost of repairs per acre per year in the several localities is given in the following table:—

Serial No.	Name of the place.	Average cost of repairs per acre per year.			Remarks.
		Rs.	a.	p.	
1	Tamnath ...	6	0	0	The place lies at the foot of hills.
2	Tivre ...	4	8	0	
3	Vave ...	5	0	0	
4	Savergaon ...	7	0	0	Do.
5	Khandpe ...	5	8	0	
6	Vadavli ...	5	8	0	
7	Mandavne ...	5	8	0	
8	Pali ...	6	0	0	Do.
9	Kadhav ...	7	8	0	The fields are very small and hence the length of bunds is great.

## V. Natural Enemies of Crabs.

Like all other animals crabs have their enemies. Man, however, seems to be the greatest among them. Numbers of crabs are caught during the monsoon when they are active and detrimental to the rice crop. Some are edible and serve as excellent food of large numbers of people. The *chimburi* species is specially liked on account of its possessing a large quantity of food material particularly in the legs. Many boys and women of the *kathodi* community can be seen regularly hunting after them in the fields, and they form part of the daily dish when they are found in plenty. Thus human agency serves as a check on the increase of crabs.

The crow also helps the farmer in controlling the crab. Early in the morning or late in the evening when some of the crabs are to be seen near the mouths of the burrows, the crows flying long distances along the crop in large numbers in search of crabs suddenly dart at them when they happen to come up and pull them out. They generally catch them by the hind legs to avoid the bites of their pincers and shake them violently. When the animal turns round to bite, the crow dashes it on the ground. After two or three dashings the animal becomes quite exhausted and is thrown on its back. The crow then pecks the soft ventral side with its beak and when once the nervous system is injured the animal dies. Numbers of carapaces and legs of animals killed by crows can be seen lying about on the *bunds*.

Thirdly, a kind of mite, white in colour has been found in numbers on the gills or inside the gill chamber in many of the specimens dissected. Eggs of these have also been found on the epithelial membrane of the gill chamber. These appear to be parasites on the gills. How far these actually help in reducing the number of crabs is still to be seen, but this mite is now under detailed study.

Rao Saheb Ramchandraro has observed in Madras that "the Pariah and Bral miny kites are confirmed enemies of the crab." Storks and crows have also been noted as its enemies. Jackals are known to hunt after them at night. A species of leech was found by Ramchandraro in the gill chambers.

## VI. Local Methods of Control.

There is no local method so far known which can be really called effective of destroying the crabs. There are

certain methods of crab collection in vogue in different places but they are all practiced more for the sake of using them for food than to save their crops. The commonest amongst these is hand collection. During the early part of the rains crabs come out at night in large numbers and the people are seen move out in parties with torches in their hands to hunt after them. Catching them by thrusting the hands in the burrows or digging them out is also skilfully practised by the "*kathodi*" tribe during the active season of the crabs.

Cowdung solution when poured into the burrows is also supposed to bring them up. In some places *karanj* (*Pongamia glabra*) leaves and the thorny skins of jack fruits (*Artocarpus integrifolia*) are finely chopped and mixed with the cowdung solution. But the device used by the *kathodi* people to fish the crabs out of the burrows when they go deeper down along with the water level is rather an interesting one. They take a long thin flexible piece of bamboo and tie at one end of it finely chopped grasshoppers and a small quantity of grass. This is thrust inside the burrow. The crab being attracted by the smell of the grasshopper comes out of the burrow when the bamboo stick is gradually pulled out and the crab is finally caught. Here again we find that animal matter, which is liked by crabs more than vegetable matter, is made use of as a bait for fishing them out.

A method of catching the crabs during the hot weather when they go deep for hibernation is also known to the people. They grind two stones together with sand in between them, near the burrow. The sound that is produced probably makes the crabs think that it is raining, and they come out.

#### VII. Trial of Remedial Measures.

We have now discussed the observations made regarding the life history and habits of the land crabs which are common in the Karjat-Lonavla area of Western India. Now remains an account of experiments made to devise remedial measures whose discovery forms the ultimate aim of the work.

The complete eradication of any pest may be effected by the following principal methods:—

(1) Hand collection or trapping in large numbers and destruction of the creatures caught;

(2) Introducing parasites which prey upon them or feeding them with poisons, the result in both cases being their death in large numbers; and

(3) Making the environment uncongenial or injurious.

Work was conducted in each of the above directions and the details of the results achieved may be given.

(1) *Hand Collection and Trapping*.—Hand collection of crabs is only possible in early June when the hungry crabs emerging from hibernation come out in numbers, especially during the early part of the night, and after heavy showers, in search of grass. As the vegetation is very poor at this time, they have to run long distances before they get sufficient food material. Light, as seen already, has a dazzling effect on crabs and can be used with advantage. In spite of all these considerations, hand collection cannot be relied upon as a means of wholesale destruction though if rigidly followed, it will considerably lessen the trouble.

Trapping of crabs in pots sunk in fields and bunds though found to be quite successful elsewhere\* has not given satisfactory results with the species of land crabs in Western India. The pots were even baited with rice seedlings, *hariali* and other grasses, fresh fish, &c., but the crabs used to feed on the baits kept on the edges of the pots without being caught. To overcome this difficulty the pots were filled with water up to the brim and the things were left floating on the surface. This attracted a greater number of crabs. The smell of fermenting paddy kept in water also served as an attracting material. But none of these methods turned out to be sufficiently encouraging to warrant adoption on any considerable scale.

Trapping the young ones is only possible to some extent in the case of the *paratelphusa* types common at Karjat because they are liberated by their mothers in the field where they move about for some days before they begin to dig their burrows. It is not possible to trap the young ones of the *Gecarcinucus*, they being liberated inside the burrows. The trap used for the purpose was obtained from the local fishermen who call it *Asu*. It is made up of thin bamboo sticks and is so constructed that when a stream of water is allowed to run into it, all the water freely escapes but the animals which get in are unable to escape and are caught. The trap was placed in the water channel in between two fields in the evening and the young ones caught were collected the next

\*Leaflet of the Department of Agriculture, Burma.

morning. No young ones were caught after July and a day's catch in a trap never exceeded sixteen. So, this method also cannot be said to be promising.

(2) *Treatment by Poisons and Introduction of Parasites.*—The best means of introducing poison into the system is by means of baits, for which a suitable medium, the right sort of poison, and the optimum dose required have first of all to be worked out. In the selection of the medium, it has to be arranged that the substance chosen is readily taken up by the crabs, is cheap and is easily available. A number of such substances were, therefore, tried in cells as in the feeding experiments and the results are as under:—

Serial No.	Name of the substance tried.	Number of trials made.	Average quantity eaten.
1	Rice Bran	14	0.65 Grams.
2	Boiled Rice Bran	13	0.55 "
3	Fried Rice Bran	2	0.93 "
4	Niger cake	2	Nil.
5	Safflower cake	2	"
6	Fried copra	4	0.24 Grams.
7	Mahoti oil cake	2	0.55 "
8	Dry fish	4	Nil.
9	Boiled rice	9	1.75 Grams.
10	Seedlings of <i>Val</i>	4	0.67 "

From these figures it is clear that boiled rice is by far the best medium among those tried for introducing poisons, and that a crab may be expected to eat any quantity of this up to two grams.

In order to see if the medium can be made more attractive by the addition of certain palatable or sweet smelling substances, feeding experiments were repeated after adding some such materials and the quantities actually eaten were noted in each case.

Serial No.	Medium used.	No. of trials made.	Name of the smelling or palatable material.	Average quantity eaten.
1	Boiled Rice	2	Oil of Bergamot	0.26 Grams.
2	Do.	2	Amylacetate	1.00 "
3	Do.	2	Benzine	0.72 "
4	Do.	2	Clove oil	0.27 "
5	Do.	2	Fish oil	0.29 "
6	Do.	2	Finely chopped grasshoppers	2.00 "
7	Bran	3	Fermented paddy water	0.86 "
8	Do.	2	Finely chopped rice seedlings	0.53 "



Out of these, only the figure for finely chopped grasshopper is satisfactory. So if grasshoppers or other similar insects are available they might be finely chopped and mixed with the bait to make it more attractive.

After thus determining the medium, the question of poison and dose only remains. For this purpose different doses of different substances likely to be poisonous were tried with two grams of the bait selected and the quantity eaten by the crab was weighed the next day. Then the effect of the substance on the crab fed was studied. The results of the trials are given in the following table:—

Serial No.	Bait fed.	Bait eaten.	Results.
1	Boiled rice + Paris Green 0.02 grams...	0.43 grams.	Died after 30 hours.
	Do. do. do. ...	Whole ...	Died after 2 1/2 hours.
2	Do. + do. 0.05 " ...	0.54 grams.	Died after 30 hours.
	Do. do. do. ...	0.71 " ...	Do.
3	Do. + do. 0.1 " ...	1.08 " ...	Died within 12 hours.
	Do. do. do. ...	1.06 " ...	Do.
	Do. do. do. ...	Whole ...	Do.
1	Boiled rice + White arsenic 0.01 grams.	0.41 grams.	The crab did not die.
	Do. do. do. ...	1.52 " ...	Do.
2	Do. + do. 0.02 " ...	1.14 " ...	Do.
	Do. do. do. ...	1.74 " ...	Died after 24 hours.
3	Do. + do. 0.05 " ...	0.85 " ...	Do. 56 "
	Do. do. do. ...	0.97 " ...	Do. 48 "
4	Boiled rice + do. 0.1 " ...	0.54 grams.	Died after 48 hours.
	Do. do. do. ...	A very small quantity.	Do. 56 "
5	Do. + do. 0.2 " ...	0.68 grams.	The crab did not die.
	Do. do. do. ...	1.24 " ...	Died after 24 hours.
1	Boiled rice + Strychnine sulphate 0.01 grams.	0.54 grams.	The crab did not die.
	Do. do. do. ...	0.77 " ...	Died after 120 hours.
2	Do. + do. 0.02 grams ...	0.72 " ...	The crab did not die.
	Do. do. do. ...	0.83 " ...	Do.
3	Do. + do. 0.03 grams ...	0.09 " ...	Do.
	Do. do. do. ...	0.66 " ...	Died within 12 hours.
	Do. do. do. ...	Nil ...	The crab did not die.
4	Do. + do. 0.1 grams ...	1.1 " ...	Died within 12 hours.
	Do. do. do. ...	0.31 " ...	The crab did not die.
	Do. do. do. ...	0.55 " ...	Do.
1	Boiled bran + Washing soda 0.2 grms.	0.51 grams.	The crab did not die.
	Do. do. do. ...	0.61 " ...	Do.
1	Boiled rice + Plaster of Paris 0.1 grms.	0.05 grams.	The crab did not die.
	Do. do. do. ...	0.2 " ...	Do.
1	Boiled rice + Barium carbonate 0.1 grams.	0.08 " ...	The crab did not die.
	Do. do. do. ...	Nil ...	Do.
2	Do. + do. 0.2 " ...	0.23 " ...	Do.
	Do. do. do. ...	nil. " ...	Do.
1	Boiled rice + Copper sulphate 0.2 grams.	0.13 grams.	The crab did not die.

Serial No.	Bait fed.	Bait eaten.	Results.
	Boiled rice + Copper sulphate 0.2 gram.	1.09 grams.	The crab did not die.
1	Boiled rice + Calcium chloride 0.2 grams.	0.83 " ...	The crab did not die.
	Do. do. ...	0.11 " ...	Do.
1	Boiled rice + lime 0.05 grams ...	0.26 " ...	The crab did not die.
	Do. do. ...	0.16 " ...	Do.
2	Do. + do. 0.1 " ...	Nil. ...	Do.
	Do. do. ...	Nil. ...	Do.
1	Boiled rice + Red oxide of iron 0.05 grams.	0.16 " ...	The crab did not die.
	Do. do. ...	0.11 " ...	Do.
2	Do. + do. 0.1 " ...	0.21 " ...	Do.
	Do. do. ...	0.31 " ...	Do.
1	Boiled rice + Alum 0.05 " ...	Nil. ...	The crab did not die.
	Do. do. ...	Nil. ...	Do.
	Do. + do. 0.1 " ...	Nil. ...	Do.
	Do. do. ...	Nil. ...	Do.
1	Boiled bran + Washing soda 0.2 grams.	0.51 " ...	The crab did not die.
	Do. do. ...	0.61 " ...	Do.
1	Boiled rice + Common salt 0.1 grams.	0.95 " ...	The crab did not die.
	Do. do. ...	1.05 " ...	Do.

From all this study, it is clear that Paris Green is the best poison tried. Next comes white arsenic. If strychnine sulphate is used in a strong dose, the crabs do not eat the baits at all. A weak dose is not effective. Among the other things tried none was found to be successful. The poison bait should, therefore, consist of about 2 grams of boiled rice with about 0.1 grams of Paris Green. Grasshoppers or other insects if available might be mixed with it in a finely cut condition to render them more attractive.

The best time of trying poison baits is in June when in the absence of sufficient vegetation, the crabs will readily feed upon these baits and thus fall victims. If a small quantity of glycerine is added to the baits when they are being prepared, they remain fresh for a long time, and can be used for some days. The baits should be kept in the fields in the evening after sunset and those that are not eaten be picked up the next morning for using again.

The next question is as to the possibility of the inoculation of parasites. The only parasite that has been noted in the crab is the white mite already described. Crabs kept in glass jars in water were inoculated with these parasites, but the effect on the health and activity of the crabs was not very noticeable.

(3) *Making the Environments uncongenial and injurious to Crabs.*—In modifying the environment so as to make it uncongenial to the crab, we are almost restricted to the possibility of introducing something into the water and the air which will be objectionable to the animals. The present is an attempt to describe the different sets of experiments laid out with a view to alter the water and air in which they live in such a way as to be harmful to them. It must be remembered here that crabs remain in water inside their burrows, and that this water is taken into the gill-chamber for respiration. If it were possible to find out substances which when thrown into the water would produce an extract or solution harmful to the tender gills, then it would be very easy to control the crabs. There are known to exist a number of vegetable poisons commonly used by fishermen, which when finely chopped and thrown into a pond or stream with fish have the effect of killing large numbers of them in a very short time. With the object of finding out similar substances a set of experiments to try the effect of the extracts or solutions of different substances on crabs was arranged in the laboratory in small cells. The cells were filled with such a quantity of the extract or solution as was necessary just to immerse them but yet to enable them to breath oxygen from the air. The results of the experiments are arranged in the following table :—

Serial No.	Substance tried.	Strength of the solution.	Result.
1	Red oxide of iron	Per cent.	The crab did not die even after 72 hours.
2	Extract of <i>Rameta</i> * ( <i>Lasiosiphon eriocephalus</i> ).	...	
3	" <i>Shirid</i> * (?)	...	
4	" <i>Sherkodi</i> * ( <i>Euphorbia tirucalli</i> ).	...	
5	" <i>Bhogeda</i> * (?)	...	
6	" <i>Supali</i> * ( <i>Elitoria ternatia</i> ).	...	
7	" <i>Shembati</i> * ( <i>Acacia pennata</i> ).	...	
8	" <i>Phangali</i> * ( <i>Pogo-tomon parisflorus</i> ).	...	
9	" <i>Gela</i> * ( <i>Randia dumetorum</i> ).	...	
10	" <i>Nirgudi</i> ( <i>Vitex negundo</i> ).	...	
11	" <i>Karanj</i> ( <i>Pongamia glabra</i> ).	...	
12	" <i>Nim</i> ( <i>Azadirachta indica</i> )	...	
13	" tobacco stalks	...	

\*These are plants used by fishermen for killing fish.

Serial No.	Substance tried.	Strength of the solution.	Results.
14	Extract of <i>carisa siamea</i> ...	Per cent. ...	The crab did not die even after 72 hours.
15	" <i>Euphorbia nivulia</i> ...	" ...	"
16	" cotton cake ...	" ...	One crab died within 16 hours and the other did not die even after 72 hours.
17	" <i>Adulsa (Adhatoda vasica)</i> ...	" ...	One crab died after 16 hours and the other after 74 hours.
18	Solution of Calcium chloride ...	" ...	The crab did not die even after 72 hours.
19	Solution of gypsum ...	" ...	One crab died after 16 hours and the other did not die even after 72 hours.
20	" of Ammonium sulphate ...	3	The crabs died after 12, 18, 28 and 45 hours respectively.
21	" Nitrate of Soda ...	3	The crabs died after 47 and 72 hours respectively.
22	" Superphosphate ...	" ...	The crabs did not die even after 72 hours.
23	" Alum ...	1½	The crabs died after 15 and 92 hours.
24	" Fish oil rosin soap ...	2	One died after 27 hours and the other did not die even after 72 hours.
25	" Incosopol ...	2	The crabs did not die even after 72 hours.
26	" Washing Soda ...	½	Died after 16, 24, 9 hours respectively.
	" " ...	1	Died after 16 and 16 hours respectively.
	" " ...	2	Do.
	" " ...	3	Died after 6, 8, 8½ and 8½ hours respectively.
27	" Slaked lime ...	½	Died after 24 and 35 hours respectively.
	" " ...	1	Died after 24, 12, 8, 9, 11, 8 hours respectively.
	" " ...	1½	Died after 9, 9, 11, 11 hours respectively.
	" " ...	2	Died after 12, 12, 17 hours respectively.
	" " ...	3	Died after 12 and 24 hours respectively.
28	" Potassium sulphate ...	3	Died after 24 and 36 hours respectively.
29	Extract of castor cake ...	" ...	The crab did not die.
30	Solution of cowdung ...	" ...	Do.

Of all these materials tried, only washing soda and slaked lime are effective in killing crabs, though the results are slightly varying probably according to the vigour and sustaining power of the individuals tried. The first one of these may be entirely left out of consideration being injurious

to plant growth. The only thing that remains is slaked lime. On a field scale, when it is to be applied, water should be made to stand in the field only to a depth of five to six inches and fine air slaked lime dusted in a strip of four to five feet in width all along the *bunds*, the crab burrows being mostly situated in these places only. If applied in this way, 1 to 1½ tons of lime are required per acre.

Another method of changing the water environment is to raise the temperature. In the study of temperatures it has been seen that if the temperature rises beyond 100°F (equal to nearly 38°C) the crabs living in it are sure to die. This can be achieved in two ways, either by adding chemicals or by pouring boiling water in sufficient quantity to raise the temperature of the inside water to at least 100°F. Among chemicals might be mentioned calcium carbide which will be discussed later on. When one gallon of boiling water was poured it was found that the crabs inside were alive when there was water below, but were killed when there was no water. Similar results were also obtained with 2 gallons of boiling water. Larger quantities were not tried, as it would be beyond economic limits to do so even if it were found successful.

Next comes the air environment. The crab though it remains under water breaths air directly also, and if it would be possible to pump in or produce gases or fumes that would be poisonous to the crab inside the burrow, it would be very easy to destroy them. To determine in the first place what fumes are poisonous, different gases and fumes were tried on crabs kept in cells. The results of the experiments are tabulated below :—

Serial No.	Nature of the fumes tried.	Results.
1	Carbon bisulphide	Died within half an hour.
2	Methylated Spirits	Died within 4 hours.
3	Methylated Spirits with Napthaline dissolved in it.	Died within 2½ hours.
4	Kerosine	The crab did not die even after 12 hours.
5	Kerosine with napthaline dissolved in it.	Died within 9½ hours.
6	Terpentine	One crab died within 5 hours and the other was able to live even after 24 hours.
7	Absolute alcohol	Died within 3 hours.
8	Petrol	Died within 2½ hours.
9	Petrol with Napthaline dissolved in it.	Died within 2 hours.
10	Ammonium carbonate	Died within 3 hours.
11	Acetylene	Died within 8 hours.

It can be seen from this table that carbon bisulphide gives the best results. Because the fumes of this are deadly poisonous and being heavier than air do not escape so readily as the others. Then come petrol and methylated spirits. The action of these is accelerated by the addition of naphthaline to them. Acetylene gas produced by the action of water on calcium carbide kills the crabs within eight hours but if a piece of carbide is thrown in water in a cell with a crab, the crab dies within a couple of hours. Here the lime produced and the heat evolved in the chemical change play their part as well and thus quicken the action.

After thus determining the extent to which various fumes are poisonous, the question now remains of finding out how, when and in what quantity these are to be used by actual experiments in the field. The results of the trials of these are discussed separately.

*Carbon Bisulphide.*—After a number of trials it has been found that only about three grams which comes to about three-fourths of a drachm is sufficient to kill the crab in a burrow. First of all this quantity of the substance was poured on a little cotton which was thrown into the burrow and the burrow closed with soil immediately to prevent the escape of the fumes. Later on it was found that simple putting in of the drops and subsequent closing with soil gave equally good results. Nearly forty burrows were treated which all remained closed. Eight of them were actually dug and dead crabs were found inside. This leaves no doubt about the efficiency of this substance. It can be used any time from June to October when all the burrows are open, and when the burrows can be easily closed, the soil being quite wet. To treat one acre about five pounds of the substances will be required according to the intensity of crab infestation. Carbon bisulphide has thus been found to be an effective and very useful substance, though on account of its dangerous nature it has very carefully to be handled. It is fairly cheap.

*Methylated Spirits and Petrol.*—The time and method of treatment with these substances which we have employed is much the same as with carbon bisulphide, but the dose must be much bigger. About 25 cubic centimeters were employed for each burrow and the results were similar to those obtained with carbon bisulphide.

*Calcium Carbide.*—Finding calcium carbide useful in a cell in the laboratory a few trials were given to it in the

field. The difficulty with this is that it requires the presence of water for the necessary chemical change to take place. In the month of July when the burrows were all full of water, small pieces of carbide about two tolas in weight were dropped into the burrows and the openings closed. The next day all the burrows were examined. In nearly fifty per cent. of them the crabs had escaped after effecting a fresh entrance just near through the soft soil. The trials were repeated in the hot weather when the soil had become hard, but as the water level had sunk much deeper now, some water was poured on the piece of carbide so that it might run into the water below. Some of these burrows were dug to see the result and it was found that in some cases the pieces of carbide had not at all reached the bottom, but had decomposed half way where the burrows were more or less horizontal. And the crabs inside also were alive. Treatment with calcium carbide is, however, likely to succeed in Sind, where the burrows are almost vertical, but at Karjat the results were not satisfactory.

*Sulphur and Arsenic Fumes.*—These fumes were pumped into the burrows, all the openings of which were first traced out by passing in ordinary smoke by means of the well known smoking machine known as the "White-ant Exterminator" and then closed. These burrows were reopened the next day thus indicating that the crabs were not killed. It must be recognised, however, that our experiments in this direction have barely commenced. Similar experiments were made with tobacco and chilli smoke but with similar lack of success.

### VIII. Recommendations.

I venture to make a number of provisional recommendations in order to minimise the damage done by the species of crabs in Western India in connection with rice cultivation. They are purely provisional, but are based on my study of the habits and life history of crabs usual in this area.

These recommendations are as follows :—

1. The surface of rice fields should be maintained in a perfectly level condition, so that water should stand equally deep all over. The borders of the fields are generally raised up, and thus harbour large numbers of crabs. These borders should be brought to the general level of the field every year by removing soil, if necessary.

2. The embankments (*bunds*) should be reduced as far as possible without in any way disturbing the regular distribution of water all over the field. They should be strong, well kept and repaired whenever necessary. By these means it would be possible to lessen the extent of damage considerably.

3. The water supply of the field should be kept up as long as possible for the species usually found at Karjat. In the case of water-loving species complete drying up of the fields at intervals, if it can be practised without any detriment to the crop, is advisable.

4. Poison baits may be tried in the early part of the monsoon. They should be made up of about two grams of boiled rice and 0.1 gram of Paris Green for each. If grasshoppers or similar other insects are available, they should be caught, finely chopped and mixed with the baits. A small quantity of glycerine also should be added. The baits thus prepared should be kept near the burrows late in the evening to prevent crows from eating them. Those that are found uneaten the next morning should be picked up. The presence of glycerine allows the use of the same baits for four or five days.

5. Fine air slaked lime may be dusted in the fields preferably before transplanting in strips four or five feet wide all along the *bunds* when water is standing in the field to a depth of 5" or 6". One to one and a half tons of lime will be required per acre. In the case of crabs which are found all over the fields, lime will have to be distributed all over and in such cases larger quantities of lime will be required.

6. Fumigation is the best and surest method of destroying crabs in their burrows. It can be practised any time from June to October when all the burrows are open. Carbon bisulphide, petrol and methylated spirits, may be used. Out of these carbon bisulphide gives very satisfactory results. At the rate of three grams (that is to say about three-fourths of a drachm) per burrow, an acre will require on an average about five pounds of the substance. The drops are simply to be put in and the burrows to be immediately closed with soil. To facilitate the work of dropping tin cans of the fashion of lubrication oil cans may be used. As all the openings do not lead to deep going burrows, which alone harbour crabs, only those



which appear to be deep going should be treated on the first day, but the surrounding apparently superficial ones should also be closed to prevent the escape of fumes through them. If on the next day any of these supposed superficial burrows be opened, they might be taken for deep going ones and similarly treated. It is in this way possible easily to eradicate the pest from large areas at a very little cost. The only thing is that the material has to be carefully handled.

The action of petrol and methylated spirits can be hastened by dissolving small quantities of naphthaline in them. But for them a larger dose of about 25 cubic centimeters (one ounce) for each burrow is required. Their use is exactly similar to that of carbon bisulphide in the method and time of treatment. They are very cheap, easily available, and can be used by any body.

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## WORK DONE BY THE AGRICULTURAL DEPARTMENT IN THE SOUTHERN DIVISION DURING THE YEAR 1922-23.

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### Organisation.

The principle of organisation in the sections each responsible through its head to the Deputy Director of Agriculture continued. Under retrenchment the post of the Divisional Superintendent was kept vacant from 1st September 1922. The strength of the District staff was, however, increased to a certain extent. Each district has during the year been under the Inspector responsible as a head of section to the Deputy Director of Agriculture. The Inspector of Agriculture, Dharwar District, has two fieldmen, one graduate working from the Haveri Centre and the other non-graduate working from Gadag. The Inspector of Agriculture, Belgaum District, has also two fieldmen, one graduate with head-quarters at Chikodi and the other non-graduate at Bailhongal. The Inspector of Agriculture, Bijapur District, has one non-graduate fieldman with head-quarter, station at Bagalkot. There was no material change in other sections.

2. The Boring staff and the Mechanical Assistant were transferred to the control of the Deputy Director of Agriculture from that of the Agricultural Engineer, Bombay Presidency, Poona from 1st February 1923.

The Agricultural Organisers were also transferred to the control of the Deputy Director of Agriculture from that of the Assistant Registrar, Co-operative Societies, S. D., during the year under report.

On demand from the people a separate officer for advice on the embankment of land was considered necessary and a graduate fieldman was selected from 1st September 1922 to study the subject and do this special work.

3. The Deputy Director was the Chairman of the Divisional Board the organisation of which was referred to in the last year book, and he conducted four ordinary quarterly meetings of that Board.

4. The work done by various sections will be summarised under the following heads:—(a) Experiments, (b) Propaganda, (c) Agricultural Education and (d) Miscellaneous.

### Experiments.

5. Experiments were conducted mainly on Government Farms, Dharwar, Gokak, Gadag and Tegur and a few in cultivators' fields.

6. *Dharwar Farm*.—Is rising in importance mainly as a plant breeding station. The breeding work, is steadily extending, and is becoming more useful to the public. In cotton the cross between Dharwar No. 1 and Rosia which reached its 5th generation engaged main attention. Up till the 4th generation, selection was based on three characters, *viz.*, high ginning, long staple and white colour. In the 5th generation the number of plants pure for all these 3 characters being found sufficiently large, 120 plants were selected specially for high yielding character. All these are derived from 3 plants of the 2nd generation of the cross and seem to have a great future. In previous years a small number of low ginning plants was traced in lines pure for high ginning. The cause of this discrepancy had not been found out. This year on detailed observations wilt was found to be the cause of it. On the same plant kapas from affected branches gave lower ginning percentage than that of healthy branches. Wilt seems to be a disturbing factor in the case of ginning percentage and further investigation on this point will be continued. Work done on wilt is treated in a separate article by Mr. Kottur.

8. The usual selfing and selection work on Dharwar No. 1, and Gadag No. 1 Cottons was attended to. 300 lbs. of Dharwar No. 1 and 200 lbs. of Gadag No. 1 seed were produced for multiplication. Observations on the cross Gadag No. 1 and Sea-Island Cottons continued.

9. Breeding work on *jowar* consisted mainly in purification of some of the important varieties and selection in local varieties for yield. *Chavari Nandyâl*, *Bilichagan* (*Striga* resistant) *Wagar*, *Holigi*, *Gidigempu*, *Ranebennur*, *Fulgar white*, *Fulgar yellow*, and *Handi Masdi* (white grained) were pure and true to type. *Holigi* is an early variety and flowers at the end of September. If cut at this time it ratoons well and gives good yield in the rabi season. Selection

for yield was done in Fulgar yellow, Fulgar white, Nandyal and Mahisal varieties. A certain amount of selection in Local wheat was done on the bases of the number of spikelets per spike. In order to study the relation between the weight of grain, and the length of rachies measurements and weights of 500 individuals in Nandyal and Fulgar varieties have been recorded and the figures are being worked out.

10. Other experiments conducted by the Superintendent of the farm were on crops, on manures, on cultures and on field embankments.

12. *Crop Experiments.*—Comparison between Dharwar No. 1 and Kumpta Cotton was important. Dharwar No. 1 yielded less than Kumpta due to greater attack from wilt, but as it received better prices for *kapas* fetched nearly the same net profit per acre. Dharwar No. 1 has a great future if the wilt problem is solved. The attack of wilt is not so much in cultivators' fields, as is on the farm and cultivation of Dharwar No. 1 is steadily extending. The trial of Lucern as a dry crop for green fodder gave very encouraging results. 18,386 lbs. green fodder valuing Rs. 244 was obtained in six cuttings at a cost of Rs. 105 giving a net profit of Rs. 139 per acre. The trial of tobacco was encouraging and will be repeated during the next season.

13. *Manurial Experiments.*—Application of 10 tons farm yard manure per acre every second year to the *jowar* crop has given the best results and that of 15 tons per acre is found to be paying. Crude night soil applied to a plot in 1914-15 at the rate of 20 tons per acre is still showing its effects on the *jowar* crop. Average results of the experiment of ploughing in farm yard manure versus spreading this manure conducted for the last 8 years are in favour of spreading the manure.

14. *Cultural Experiments.*—Deep versus shallow tillage experiment in clean black land is in favour of the latter. Disking is found to be better than ordinary ploughing once in two years. Experiments for eradicating *Striga lutea* were in progress and will take sometime more before any recommendation can be made.

15. Dharwar Farm besides conducting experiments continued to maintain an Implement Depot and a Work Shop attached to it. In all, implements worth Rs. 3,096 were sold.

16. *Gokak Farm*.—The Superintendent of this farm worked mainly with a view to make the farm paying and conducted many useful experiments as well.

17. *Manurial Experiments*.—Artificial manure to cane crop was given with advantage in three doses instead of only once at the time of earthing up. Trash manure to the *cane* crop gave good results and needs recommendation to cultivators of *cane* in the canal tract. Green manuring with gram in the rabi season has given better results than that with sunflower on the succeeding maize crop and green manuring with san in the kharif season was better than that with sunflower for succeeding rabi jowar crop. Top-dressing paddy with oil cake manure at the rate of 10 to 20 lbs. nitrogen per acre was found to be very paying and deserves recommendation to cultivators. Top-dressing turmeric with oil cake at the rate of 40 lbs. nitrogen per acre in addition to ordinary dose of  $7\frac{1}{2}$  tons farm yard manure has considerably increased the yield and net profits.

18. *Crop Experiments*.—In the trial of cane varieties, Yellow Mauritius has attracted attention. It gives better germination than others in sticky and karl soils. It is less attacked by borers, is more drought resistant than Pundia and its *gul* is better than that of Red Mauritius, and as good as that of Pundia. This variety has scope in sticky and karl soils in the Gokak Canal tract. Dharwar No. 5 Cotton has given better results than Dharwar No. 3. Seed has been preserved for extensive trial in cultivators' fields.

19. The garden of Gokak Farm has been now a paying concern. The method of slow irrigation and concrete channel were prominent features in orchard management. The alkali land on the farm has considerably improved and has produced good crops of paddy and cotton.

20. Besides field experiments the farm undertook experiments on storage of *gul* and methods of killing pigs and jackals. Maize silage was prepared after removing cobs with great profit. 600 bags of cake manure was sold from the farm depot to the cultivators of the canal tract. The total sale proceeds of the depot have gone to Rs. 5,100 which reflects credit to the farm.

21. *Gadag Farm*.—Experiments on Gadag Farm totally failed owing to failure of rains and there is nothing worth recording.

22. *Tegur Farm.*—The herd of cattle is now well established. The progeny of the new bull is better than that of the previous ones. All cross-bred bullocks have fetched a better price than country ones. A good quantity of fodder was grown in the kharif season at a cheap cost.

23. Observations on grasses and methods of hay and silo making continued. The disease *Strongylus contortus* was traced and all precautionary measures were adopted. Treatment with copper sulphate solution was found very valuable for keeping up the condition of cattle and for preventing the spread of the disease.

Sheep maintained on the farm also did well. It is hoped that Tegur Farm will soon be in a position to demonstrate the advantages of mixed farming in the Mallad tract where lands are lying waste.

24. *Mugad Farm.*—A Rice Breeding Station was established at Mugad six miles from Dharwar at the close of the year under report. Many sites were inspected in different places of the rice tract and one was finally selected at Mugad.

25. *Experiments in Cultivators' Fields.*—The District staff conducted a number of experiments with bone meal and cake manure to the paddy crop and oil cake and sulphate of ammonia to the cane crop. Trial of early variety of groundnut was undertaken in three new places in Belgaum District and four in Dharwar District. Bansi wheat was compared with local in three places. Trial of turmeric at Devihosur in garden land gave very encouraging yields and its cultivation is likely to extend in cocoanut gardens situated in the belt running from Hangal to Haveri in the Dharwar District.

#### Propaganda.

26. *Demonstrations.*—In all 30 demonstrations were conducted in Dharwar, 40 in Belgaum and 8 in Bijapur Districts. Most of them were of improved implements notably of iron ploughs, wheat thresher and stone roller for threshing jowar. A few were of cane crushing with Nahan mill and gul making on Poosa furnace and others were of standing crop in experimental plots in cultivators' fields above referred to. Some demonstrations were arranged in Co-operative

Union Centres and along with Co-operative Conferences. Ploughing competitions were held in three places in Belgaum, two in Dharwar and one in Bijapur Districts. All demonstrations were followed by lectures on useful subjects and many included steeping *jowar* seed in copper sulphate solution.

27. Exhibitions of agricultural produce were arranged along with Aminbhavi and Alur Co-operative Conferences and with a cattle show at Aminbhavi. A training class was arranged on Dharwar Farm for Secretaries and members of Non-Credit Agricultural Societies. A series of lectures on different subjects were given to them and handling of various ploughs and other implements were also taught to them.

28. *Distribution of Improved Implements, Manure and Seed to Cultivators.*—As a result of our experiments and demonstrations in cultivators' fields, the demand for improved implements (chiefly iron ploughs and Nahan mills) bone meal, cake manure and sulphate of ammonia is steadily increasing. After the close of the Belgaum Depot, the Union Agency, has captured the market for sulphate of ammonia and Messrs. Gavade and Shirgaonkar for Nahan mills. The total sales of implements and manures by these two private firms reached to Rs. 25,000 during the year. I have already stated in para. 20 that Gokak Farm sold 600 bags of cake manure. Many local middle men also deal in this cake manure and bone meal. The business of hiring out iron ploughs is mainly taken out by Associations and Co-operative Societies in Dharwar and Belgaum Districts, and by middle men in the Bijapur District. A Government depot was started at Bailhongal at the demand of the people and the total sales of iron ploughs there have reached to Rs. 1,048. The next step under contemplation is to start there a Co-operative Society. The Keatinge Implement Depot at Devihosur is doing very good work.

29. *Associations, Non-credit Agricultural Societies and Taluka Development Associations.*—Among old associations Dharwar District Agricultural Association continued to do good work of hiring out iron ploughs, and its magazine is running but needs improvement. The association completed its new building and got it opened by Dr. Mann, the Director of Agriculture, B. P., Poona, with Mango Show

arranged inside the building. The Athani Taluka Association also did good work of hiring out iron ploughs and has undertaken boring work by purchasing a machine. This body has applied for registration under the Co-operative Act, and has changed its name to Taluka Development Association. Saundatti and Benadi Associations newly started for hiring out iron ploughs are steadily extending their business. All other old associations have remained inactive. Co-operative Non-credit Agricultural Societies started for supply of improved implements, seed and manure and for hiring out iron ploughs are in general slowly but steadily increasing their business. There are 37 such societies in the Southern Division and among these Hosriti Seed and Implement Society, Devihosur Seed Society and Belladbagewadi Manure Society deserve special mention. Success of these societies I think largely depends upon educating the minds of cultivators "to forecast their indents" otherwise the middle man has always his place and part to play.

30. *Taluka Development Associations.*--The organisation of these associations was planned by Government and notified in the Press Note No. 2962, dated 21st October 1921, Revenue Department and they have been started in the Dharwar, Gadag and Ron Talukas of the Dharwar District, Athani, Chikodi and Gokak Talukas of the Belgaum District and Indi Taluka of the Bijapur District. The District staff was busy in surveying the local agricultural needs of these talukas and preparing programmes of their work and budgets. All associations have approached the Director of Agriculture for Government subsidy and all except Gadag have approached the Registrar for their registration under the Co-operative Act. Dharwar, Gadag and Ron got their subsidy and commenced their work during the year. Dharwar Taluka Development Association did good work. Four ploughing and four steeping demonstrations were conducted in different centres. Boring work was undertaken. Intensive propaganda on steeping jowar seed was done in the area of the Aminbhavi Union. An Education Society at Gadag and Mango Cultivation Society at Aminbhavi are being worked. Other associations have just appointed their fieldman. Agricultural surveys prepared by the District officers reveal a big field for development and a great responsibility for these taluka bodies. Separate space has been allotted in this year book to two articles dealing with surveys of Dharwar



Taluka and Mundargi Petha. The Divisional Board had its four quarterly meetings and one special meeting in which agricultural improvements and the lines of organisations were discussed. The Co-operative Institute played an important part by holding training classes and conferences to educate the minds of cultivators to organise among themselves and take to better methods of crop production and marketing.

31. *Organisation and Campaign against Wild Pigs.*—The villages in the Mallad bordering the forest area suffer much from the attack of wild pigs to their crops so much so that the very existence of the people is being threatened out. No attempts to introduce agricultural improvements are likely to be successful there without organisation to fight out the pig.

32. Personally much of my attention was devoted to this subject. Four new Co-operative Fencing Societies were organised in Kalghatgi Taluka and walls of the type of that already built at Mandihal but of bigger dimensions (3 feet at the bottom  $1\frac{1}{2}$  feet at the top and 5 feet tall) are being built. In three villages construction is nearly completed and in the fourth it is fast in progress. Attempts to induce all the people of a village without exception to join the scheme fixing the exact line of fence to suit all but to run as straight as possible and the question of dividing the estimated cost of fence among the members, took a great deal of my time and energy in organising these schemes. The estimated benefits of these schemes are immense but only experience will tell us how much will actually be realised. Many such schemes are under contemplation in Kalghatgi Taluka. Some western villages of Mundargi Petha also suffer much from the attack of wild pigs. There prickly pear has become the abode of pigs. A site at Tambargundi was cleaned of its pear growth during the year through an unregistered co-operative organisation, at nominal cost to individual cultivators but with great benefit to them. Mr. V. H. Naik, the Deputy Collector of that Division, took interest in the scheme and has helped it with a tagavi loan from Government. A campaign for removal of prickly pear from the whole of Mundargi Petha is under consideration, and is being worked out, and this work against pig has been largely appreciated by the cultivating public.

32. *Organisation for Steeping Jowar Seed.*—In copper sulphate solution against smut through officers of the Revenue Department was planned in obedience to G. R. No. 6799, dated 19th February 1923 and demonstrations were held in all taluka centres by the District staff. 29,000 copper sulphate packets in Dharwar District, 18,500 in Belgaum District and 12,000 in Bijapur District have been distributed. Further propaganda is in progress.

33. *Cotton Work.*—Extensive trials of Dharwar No. 1 Cotton seed against Kumpta in 9 places and Gadag No. 1 Cotton seed against Dharwar-American ordinary in three places were undertaken. Results are on the whole in favour of the introduced improved types. The Cotton Superintendent with the aid of his staff distributed farm seed as usual to seed growers and controlled an area of 5,618 acres under Dharwar No. 1 and 7,136 acres under Gadag No. 1 Cottons to raise seeds for general distribution. The total area under pure seed of known origin of the two introduced varieties estimated by the seed distribution done by Sale Societies and the Savanur Centre was 33,983 acres under Dharwar No. 1 and 45,456 acres under the Gadag No. 1.

Crop demonstrations were held in different centres and good propaganda was done through cotton staff and seed organiser to induce cultivators to sell their *kapas* through Sale Societies. Rao Saheb Shirhatti, Secretary of the Hubli Cotton Sale Society, undertook with the aid of our cotton staff propaganda during the year in favour of clean picking of *kapas*, and worked hard on it. The propaganda was much hampered by unusual rains in March but has left a good impression on the minds of the cultivators. A good deal of cotton was picked clean, and prices were awarded by the Hubli Cotton Sale Society, in whose auctions it received exceptional prices.

Hubli Society mostly dealt with Dharwar No. 1 Cotton and Gadag No. 1. Other Sale Societies sold mostly Kumpta-Ordinary. In all 12 auction sales were held and grading work was done under the supervision of the Cotton Staff. On an average Dharwar No. 1 fetched Rs. 18 more per *naga* than Ordinary Kumpta, and Gadag No. 1 Rs. 40 more than Dharwar-American Ordinary. The Cotton Superintendent estimates that an extra profit of Rs. 1,22,281 was realised from these auction sales. The success of auction sales largely depends upon improved types of cotton and it is mainly

why in other centres than Hubli and Gadag the business is small. The general distribution during the coming season the Hubli Sale Society has stocked 534,180 lbs. of Dharwar No. 1 Seed at Hubli and the District Agricultural Association, Dharwar, has stored 120,000 lbs. at Savanur. The total quantity will suffice for 70,000 acres nearly double the area that was sown during the year under report. The Gadag Cotton Sale Society has stocked 363,793 lbs. of Gadag No. 1 Cotton seed almost equal to that stored during last season. The business done by various Co-operative Cotton Sale Societies is treated in a special article in this year book (*vide* page 43).

34. *Other Important Sale Societies.*—A Chillie Sale Society at Byadgi sold 4,858 maunds (of 80 lbs. each) of chillies worth Rs. 39,357. It is reported to have done good business but failed to follow some co-operative principles. A Tobacco Sale Society was started at Nipani and it has just commenced its operations. A Betal-leaf Sale Society at Hattimattur is being worked out.

35. *Cattle Breeding Societies.*—They are 12 in the Division, 6 in the *Mallad*, 2 on the bank of the river Krishna and 4 in the dry tract of Mundargi Petha along the Kapad hills. The societies in Mundargi Petha have suspended their work owing to failure of rains while the rest are reported to be working fairly well. Good cultivators have appreciated the introduction of the Mysore strain of cattle, but management in societies is not very satisfactory. The necessity of castrating mongrels is not realised by the members. The organiser for the Cattle Breeding Societies has received applications for more societies but is asked to concentrate on improving the condition of those existing at present.

36. *Boring Work.*—In all 18 bores were taken in the Division, the following are the details:—

Name of District.	Successful.	Failure.	Rejected at owners' request.	In complete.	Total.
Dharwar ...	10	0	2	1	13
Belgaum ...	2	1	0	1	4
Bijapur ...	0	1	0	0	1
Total ...	12	2	2	2	18

Ten out of 18 bores were purely for agricultural purpose.

The work was more or less stopped during rains. Out of 5 machines only 3 worked during the year. The total receipts amounted to Rs. 4,176, whereas the expenses came to Rs. 3,352. The number of applications for boring is increasing, but it is not possible with the present number of machines to cope with the demand. It was suggested during the year that local boards should get men trained to work their machines. The Taluka Local Boards, Navalgund and Shiggaon, sent their men for training. A Mechanic has been lent to the Athani Agricultural Association. Gadag and Hubli Taluka Local Board machines were worked for a time under the supervision of the Boring Assistant and their men were trained.

37. *Field Embankments.*—A special officer appointed for this work spent much of his time in studying the subject. He has prepared 9 plans in the Dharwar District and 9 in the Bijapur District. Execution of two of these schemes has been undertaken and that of the rest will begin after the rains. Some plans largely deal with prevention of surface erosion and conservation of moisture, while others offer problems of controlling fairly large nalas with a view to accumulate silt.

#### **Agricultural Education.**

38. The Vernacular Agricultural School at Devihosur continued to prosper. 22 students were on the roll, but one left in the middle of the second term. Applications for admission were many but rigorous selection was made with a view towards efficiency. A small laboratory is newly equipped and the elementary principles of some mechanical appliances which the cultivator is often required to deal with, are taught. Theory portions are commonly dealt with in classrooms for three hours between 12 a.m. and 3 p.m., while at other time of the day the students are made to work in fields with practical lessons on each operation. Each student is given fair practice in the work shop just sufficient to remove his dependence on the local carpenter or smith for petty repairs. He utilises his spare time in weaving and rope-making. Thus the students are practically busy in one or other works useful to them in their afterlife. During the year under review 9 out of 10 boys in the first year and 8 out of 11 boys in the second year have passed. The cost of educating a boy at the school came to Rs. 40 per mensem, which is high indeed. This is because great many of the subjects which

can be taught at a greatly reduced cost at the primary schools with slight additional training to the teachers there, are taught here by highly paid officers. The introduction of the proposed agricultural course into rural primary schools which is now being thought over, will solve this problem.

#### Miscellaneous Work.

39. Demand for fruit trees and for advise in fruit growing was large but could not be adequately met. 800 mango grafts were ordered from Ratnagiri and distributed mainly round Dharwar. The Inspector of Agriculture, Belgaum, attended to renovation of 10 dwindling gardens. The cultivators of the Southern Division know well how to grow crops, but are generally wanting in the knowledge of fruit growing. Here is the real field for work. A nursery and a trained mali are bad need of the Division.

40. Enclosure against pig in the *Mallad* and embanking against surface erosion which are the real needs of the cultivators in Southern Division have now been extensively taken up. The Registrar, Co-operative Societies, Bombay Presidency, kindly arranged to advance adequate loans to Fencing Societies and to individuals for embanking. He has ruled that applications for loans over Rs. 1,000 should be recommended by the Dy. Director of Agriculture. Most of the applications from individuals came from the Gadag Division of the Dharwar District and the District Agricultural Overseer, Gadag, was very busy in inspecting fields of applicants and making designs and estimates. Common embanking schemes are difficult to be worked out but a few are under contemplation.

41. The duties of District Agricultural Overseers have now been so multifarious that each badly needs a Kamgar under him for field work. I firmly believe that money spent on Kamgars is well spent. Cultivators are slow to adopt improvements and Kamgars selected from among them will play an important part in bringing out the desired progress. He will actually work with cultivators and get the advice of the Overseer acted upon.

## Progress in Jowar Breeding.

By R. K. Kulkarni, B.A., Government Farm, Dharwar.

The number of jowar varieties cultivated in Karnatak is large, but every variety, apart from the mixture of others, contains a number of distinct types. These types, it has been found, differ among other things in the quality and quantity of grain they produce. A variety may produce one kind of ear but if the individual ears are carefully examined, we shall find that they differ in their weight, in the percentage of grain and such other details. These differences are caused by external conditions such as soil, manure and moisture, in which case they are temporary and of no value. But they are also induced by internal differences, in which case they are hereditary and of great value to the plant breeder. In jowar, some of the ear characters which influence yield such as size, weight, &c., &c., are found to be hereditary and by means of these it is possible to isolate high yielding types in almost every variety. In this way we propose to improve the yield and quality of jowar crop.

Three important varieties of Dharwar, *viz.*, Haladi Fulgar, Bile Fulgar and Nandyal are being selected at present, on the lines described above. Selection alone however, is not effective. Jowar plants cross freely in the field from the pollen of other varieties brought by wind. For this reason it is necessary to protect all our selections from the contact with foreign pollen. This is done by tying a thin cloth bag to the ear. Thus by selecting the best plants and protecting them from cross-fertilisation we have been able to obtain few good types in each of the three above mentioned varieties. These are sown this year on a larger area on the farm for testing the yield and multiplying the seed.

Jowar varieties cross freely in the field and consequently deteriorate very soon if proper precautions are not taken. A dwarf variety obtained from Mahisal near Sangali is found to yield well round about Devihosur in Haveri Taluka. But this variety loses its character in few years if left to itself. By growing it continuously for 4 or 5 years the dwarf nature of the crop disappears. Other good characters also suffer in the same way. For this reason we have undertaken, for the benefit of Devihosur cultivators to grow the Mahisal variety pure on the farm and supply every year a small quantity of

pure seed. This seed is multiplied on the farm of the Devihosur school and distributed to cultivators. Similarly arrangements for keeping all good varieties pure on the Government Farm and multiplying their seed on the fields of reliable cultivators shall have to be made. We propose to undertake this work when we isolate best types from the important varieties of Karnatak.

At present we are selecting the Dharwar varieties but these may not suit other kharif tracts now growing varieties that are different from the Dharwar ones. In jowar breeding, we have certain ideas about a type that may give best results in the entire kharif area of Karnatak. This would be our ideal type and selections are being made to reach it as far as we can.

There are certain varieties which are valued for particular characters such as early ripening, popping and so on. An attempt is being made to collect such varieties and maintain them pure.

Jowar suffers from a number of diseases. The following are the more serious:—

- Striga (a parasitic plant).
- Smut (Fungus disease).
- Selorospora „
- Sugary disease „
- Stem borer (insect).

Of these the smut (*Kadigiroga*) disease can be completely controlled by steeping the seed in copper sulphate solution. Striga (*Bilichigan Kasa*) does considerable damage in certain localities. We have a jowar which suffers very little from this parasite and it may be grown with advantage by those cultivators who are thus troubled. Other diseases do not seem to yield to any treatment. But we have observed that susceptibility differs in different varieties and we may, therefore, succeed in getting types least susceptible to any of the above diseases.

## Improvement of Cotton by Breeding Wilt Resistant Strains.

By G. L. Kottar, M. Ag., Cotton Breeder, S. M. C., Dharwar.

The number of diseases, which affect the cotton crop, more or less seriously, is fortunately small in the Southern Maratha Country. The Dharwar-American Cotton, known as 'Vilayati Hatti' suffers practically from two diseases (1) red leaf blight and (2) aphis the only other trouble being from boll worm which is slight at present. The other variety, going under the name of Javari Hatti or Kumpta is liable to suffer from (1) wilt, (2) aphis and (3) boll worm. Of these the wilt occurs every year and is at present more serious than the other two. It has naturally attracted our attention first and we are trying to combat it by certain practical methods which will be described in this article.

Cotton plants die in the fields at all stages of their growth. The whole plant suddenly withers or wilts and then gradually dies. This phenomenon is familiar to all cotton growers. It is known as 'Sidi' which is an equivalent word for wilt, in Kanarese. The causes of this dying are not fully investigated but from our present experience two things are recognised as responsible for the loss, viz., (1) insects and (2) fungus (a species of fusarium). Insects especially the ground beetles cut the roots and kill the plant. Young plants with only one tap root are susceptible to this kind of damage. As the plant grows, it produces a number of side roots and if one is cut the others do its work. All the roots are very rarely cut, in fact such thing has not been observed as yet. The other thing which causes the death of plants is a kind of fungus (a microscopic plant) residing in the soil and growing on the organic matter. This enters the cotton plants by the roots and kills them by appropriating the food and especially the water. The fungus also secretes certain juices, as it grows inside and these juices, it is supposed, act like poisons in the case of cotton. Beyond this we do not know much about the fungus. It is necessary to find out how the fungus enters the soil, how it grows and how long it lives in the soil when once it enters. These and other things about the cotton wilt fungus are now being fully investigated by the Agricultural Department from the grants of the Indian Central Cotton Committee specially given for this purpose.



The fungus causing the wilt in cottons seems to be present in the whole of the Kumpta Cotton area, as we find cotton plants dying every where in advanced stage of growth. The extent, however, varies in different places or in different fields in the same locality. The loss annually caused by wilt seems to be considerable, although accurate estimation on the point is not made. The present tendency of cultivators to grow cotton after cotton in the same field is much likely to aggravate the situation. In certain villages wilt is becoming the main problem and people there are already in search of cottons that do not suffer from the trouble. For these reasons attempts are now being made to save the cotton growers from the evil effects of this disease.

The wilt fungus resides in the soil and if we can kill it by the use of certain chemicals the object will be fully gained. But the killing of the fungus by chemicals or other agents such as heat is not as easy as it appears to be. The application of these is difficult, costly and often harmful. In America the wilt fungus is said to be destroyed by soaking the land with a 2 per cent. solution of formalin or by heating. Our experience with formalin is that it costs about Rs. 1,000 per acre and even then we are not sure that the solution has reached all the spores (seeds of the fungus) in the soil. Similarly heating is also very costly and in many cases impracticable. The two above remedies, therefore, can only be of use in the case of small plots on experimental farms.

The methods of treating the soil, for getting rid of this fungus being thus impracticable, other remedial measures have been adopted and of these the breeding of types, which resist the disease is most prominent. By this method it has been possible to obtain wilt resistant cottons and tomatoes in America. We are, therefore, trying to get a wilt resistant strain of cotton suitable for the Kumpta Cotton area, by selection and crossing, and the results so far obtained are given below.

A number of cottons, cultivated in different tracts of this country, were continuously grown for some years at Dharwar. It was then observed that all varieties suffered from wilt more or less. Ghogari and Broach varieties of Gujarath fared worst while the local Kumpta Cotton suffered least of all. The following table gives the percentage

of wilted individuals found in the different varieties of cotton:—

Serial No.	Name of Cotton.	Name of the tract.	Percentage of wilted plants.
1	Ghogari	Gujarat	46
2	Broach	Do.	32
3	Jari	Central Provinces	23
4	Bani	Do.	15
5	Comilla	Assam	12
6	Kumpta	Karnatak	8

The above figures may be taken to form only a rough idea about the susceptibility of the different varieties, because the infection in the plots in which they were grown was not uniform. Knowing from this experiment, that susceptibility to wilt differs in different varieties, it became necessary to test some of the promising selections of cotton which were found to be suitable for the Kumpta Cotton tract. This was done more systematically by infecting a piece of land with sufficient quantity of wilt spores raised in the laboratory. Here also it was found that susceptibility varied in different strains. The value of the experiment, however, lay in establishing the wilt resistant character of one of the strains derived from Kumpta Cotton. The following table shows the percentage of wilt attack in Kumpta cotton and its two strains:—

Serial No.	Name of Cotton.	Description of the Cotton.	Percentage of wilted plants.
1	Kumpta	Local Cotton of Karnatak	22
2	Dharwar No. I	One pure strain of Kumpta	38
3	Dharwar No. II	Another pure strain of Kumpta	5

Dharwar No. II Cotton thus resists wilt four times more than Kumpta and it being a selection from the latter is not in other respect inferior to it. This cotton, therefore, is already ready for being introduced in parts which suffer badly from cotton wilt. Last year a trial was made with Dharwar No. II Cotton, on one of the plots of Dharwar Farm, seriously infected by wilt and the results obtained are quite satisfactory.

We have another cotton which resists wilt better than Dharwar No. II. It is derived from Burmese Cotton named Wagale. Our experience with this cotton, however, is that it is very inferior to Kumpta Cotton in other respects. We cannot, therefore, recommend it as it is. We intend to cross it with some of our best cottons to get the wilt resistant character in them. Some crosses have been made with this object and the results seem to be hopeful. There are also some wilt resistant strains in the crosses already made for improving the ginning percentage and colour of Kumpta Cotton. These are being thoroughly tested and they will be of great value if the resistant character is proved.

Thus we have one resistant cotton in Dharwar No. II which can profitably replace Kumpta Cotton in the wilt affected area. Other wilt resistant cottons superior to Kumpta in yield, ginning percentage and colour are being evolved by crossing and the progress so far made is encouraging.

### **Cultivation of Fruit Trees on the Gokak Canal Farm at Arbhavi.**

By T. S. Swadi, L.Ag., Inspector of Agriculture, Belgaum.

Fruit growing in the canal area was confined to plantains before the opening of the Gokak Canal Farm by the Agricultural Department in the year 1909. In general, Karnatak does not grow or at any rate is not noted for growing any fruit. Its markets are supplied with fruits from Goa, Benglore, Poona and other out-side centres. The object, therefore, of starting an orchard on the Gokak Canal Farm was to mainly study the possibilities of fruit growing in the Karnatak in general and the canal area in particular.

The fruit garden was started on the farm in the year 1911. Various kinds of fruit trees were obtained from Poona, Nagpur, Benglore and other well known places, for trial. Our results of the first 10 years which are now ready indicate that pomegranates, guavas, oranges, sour-limes, figs, plantains, mango, custard-apple and papaya can be profitably grown in the canal area. Foreign varieties of figs, Japanese-plums, pine-apple, chikkoo and other foreign fruits were found to be unsuited to the condition of the tract. Besides

the above, some indigenous and foreign varieties of fruit trees such as Mahaloong, Ramphal, mango-steen, pear, peaches and grapes are still under trial.

The following tables give the yield of fruit, cost of production and net profit obtained from the cultivation of three fruit trees, *viz.*, oranges, guavas and pomegranates:—

Year.	Fruits obtained.	Cost of Production.	Value of Produce.	Remarks.
<i>Oranges.</i>		Rs. a. p.	Rs.	
1911-12	...	120 0 0	...	Calculated from 94 trees from an area of 20 gunthas.
1912-13	...	36 0 0	...	
1913-14	...	45 0 0	...	
1914-16	...	60 0 0	...	
1915-16	...	60 0 0	...	
1916-17	...	60 0 0	...	
1917-18	65,184	110 0 0	1,304	
1918-19	1,680	120 0 0	34	
1919-20	11,004	120 0 0	220	
1920-21	81,849	120 0 0	750	
	Total ...	851 0 0	2,308	Rs. 1,457 net profit in the first 10 years.
<i>Guavas.</i>				
1911-12	...	70 0 0	...	Calculated from 34 trees from an area of 6½ gunthas.
1912-13	...	36 0 0	...	
1913-14	Not available.	45 0 0	11	
1914-15	Do. ...	60 0 0	110	
1915-16	Do. ...	90 0 0	143	
1916-17	52,973	105 0 0	183	
1917-18	51,798	105 0 0	259	
1918-19	52,768	115 0 0	260	
1919-20	50,652	115 0 0	254	
1920-21	27,925	115 0 0	193	
	Total ...	856 0 0	1,413	Rs. 557 net profit in the first 10 years.
<i>Pomegranates.</i>				
1911-12	...	70 0 0	...	Calculated from 68 trees from an area of 14 gunthas.
1912-13	...	36 0 0	...	
1913-14	Not available.	45 0 0	10	
1914-15	Do. ...	60 0 0	112	
1915-16	Do. ...	73 0 0	194	
1916-17	11,232	115 0 0	245	
1917-18	14,280	115 0 0	425	
1918-19	6,790	125 0 0	204	
1919-20	8,394	125 0 0	252	
1920-21	7,262	125 0 0	258	
	Total ...	889 0 0	1,700	Rs. 811 net profit for first 10 years.

The figures show that oranges have given the largest net profit; guavas and pomegranates have done fairly well. It should be, however, noted that the Gokak Canal Farm is situated far away from any good market and this fact has affected the price of fruits.

The cultivation of fruit trees generally requires some skill and experience and the following notes will, it is hoped, be of use to the fruit growers.

#### ORANGES.

*Bahar.*—The response to bahar treatment is irregular. The *Hasta bahar* crop has on an average given the maximum yield; but it must be noted at the same time that this crop is most susceptible to injury by the sucking moth—*Ophideres*, and the orange growers who wish to take this crop or the *ambabahar*, should know the proper remedy against this pest which is a simple one of catching the moths at night time when the fruits become mature. By this method the crop can be easily saved from damage.

*Pruning.*—Oranges as a rule do not require pruning, but it has been found that removing the inner branches so as to keep the centre hollow is advantageous. It encourages the proper development of fruits over larger area.

*Varieties.*—Two varieties of oranges only were tried (1) Nagpur and (2) Poona. Of these Nagpur variety was found to be better in many respects.

*Diseases.*—Die-back (antracnose) which caused the withering of branches from the tip downward is a serious disease in the case of oranges. The predisposing cause of this disease is want of proper drainage or a hard sub-soil. No remedy has been found for this as yet.

The fruits sometimes suffer from the attack of mites (a kind of insect). These can be checked by spraying with lime-sulphur wash.

#### GUAVA.

*Bahar.*—*Mruga bahar* crop gives the best yield and produces superior quality of fruits.

*Pruning.*—Guavas are not generally pruned but if the trees are pruned from the beginning they yield better fruits. Pruning consists in cutting off the last season's growth

leaving only two or three dormant buds. These dormant buds start growth soon after pruning and send out shoots which bear the present season's crop. Pruning is usually done in the month of May, before the monsoon sets in. It has been observed that by pruning, the weight of fruit is increased and the tree makes a neat and tidy growth which facilitates interculture, watching, and harvesting.

*Varieties.*—Guava seedlings were obtained from Dharwar and Poona. Those that came from Dharwar produced big fruits with white flesh and small number of seeds. The Poona seedlings produced smaller fruits with white flesh in some and red in others. Dharwar guavas though of superior quality yielded less than the Poona. Of the Poona guavas the red is sweeter than the white. In addition to these varieties a seedless kind was obtained from Northern India (Muzafarpur) for trial. It produces big fruits of irregular shape. These are practically seedless but the pulp is rather coarse.

*Diseases.*—The stems are attacked by fungus (*botryosphaera*) which causes protuberances. It does not do any damage.

#### POMEGRANATES.

*Manurial Treatment.*—40 lbs. of farm yard manure (one basketful) per tree has been found to be the proper doze. 10 lbs. of farm-yard manure supplemented by 8 lbs. of oil cake per tree has given the best result.

*Bahar.*—The treatment for *Hast bahar* has given discouraging results. The fruits from *Mruga bahar* suffer from insect attack (*Sursa* or anar-caterpillar). The *ambe-bahar* has consequently given the largest crop.

*Pruning.*—Pruning if done on previous year's growth encourages the production of larger number of fruits of better quality. The plants also respond to root exposure.

*Diseases.*—Pomegranate fruits are most susceptible to ravages from the anar-caterpillar which bores into the young fruit and makes it unfit for use. There is no chance of controlling the pest unless cultivators co-operate to destroy the fruits affected with the anar-caterpillar. The disease phomopsis causes wet and dry rot particularly in the rainy season; it can only be remedied by a thorough spray of Bordeaux mixture.

## PLANTAINS.

*Varieties.*—Seventeen plantain varieties were tried. These were of three classes. (1) Fine, (2) Middling and (3) Coarse according to the quality of fruit:—

Fine.	Middling.	Coarse.
Sonkel.	Rajale.	Gujarwali.
Safekel.	Basarai.	Bankel.
Metalwali.	Karewali.	Arewali.
Sahasraphali.	Raswel.	
Kanher.	Muthele.	
Karanjal.	Rakaswali.	
Govegiri.		
Raswali.		

The fine varieties are generally tall and produce a large number of suckers. They produce delicious fruits with thin skin. The fruits keep well and are for this season suitable for transport purposes. The yield is good but the stems being weak and tall require protection against storms.

The middling varieties are tall in habit of growth and produce many suckers; but the stem unlike the first group is thick. Basarai, however, is a dwarf variety producing few suckers. They are good yielders but the fruit is bigger in size and not so delicious.

The coarse varieties produce big fruits of inferior quality. They are in demand by the poor on account of the bulk.

These are some of the important points studied on the Gokak Canal Farm. The farm has in addition to trying the various fruit trees and studying their requirements, undertaken to supply seedlings of successful fruit trees with instructions of raising them. As a result we now find some fruit gardens already started in the neighbourhood.

## \*Note on the Survey of the Agricultural Needs of Dharwar Taluka.

By S. S. Salimath, B.Ag., Ag. Deputy Director of Agriculture, S. D., Dharwar.

Agriculturally the Dharwar Taluka naturally divides itself into two distinct tracts, the Mallad (wet rice tract) and the Gadinad (transition tract which lies between Mallad and Yerinad, the eastern dry plain). The public road from Dharwar to Gadag passes between the two and the taluka map gives the names of villages situated in these two tracts.

This note is the outcome of my experience of the taluka in general gathered from visits to various villages for different objects and the detailed special study made for the purpose for which this note is intended at and round some important centres of the two different tracts. The taluka record past and present have been consulted for comparison where needed.

### MALLAD:

(1) *Remedy against the Attack of Wild Pigs.*—This is the crying need of the tract. The trouble from the attack of wild pig to the cultivator, the damage done to his crops and the economic condition to which he is reduced are known to many. The lands adjoining the forest growth are going out of cultivation and the area under waste is increasing. The following statement compares the figures of 1892 and 1921 in a few villages:—

#### *Statement showing the Comparison of Fallow Lands in Mallad Villages in 1892 and 1921.*

Name of the village.	Waste land in 1892.	Waste land in 1921.
	Acres.	Acres.
Kotur	533	1,065
Tegur	1,338	2,025
Madikop	130	386
Belur	350	465
Khanapur	179	634
Kenchanhatti	223	446
Venkatapur	206	361
Hosawal	147	471

\* Written for the guidance of the Taluka Development Association, Dharwar, organised at Amminbhavi in accordance with G. R. No. 337 of 5th June 1922 and abridged for the year book.



Name of the village.	Waste land in 1892.	Wasteland in 1931.
	Acres.	Acres.
Durgadkeri ...	2,217	4,409
Mummigatti ...	703	1,591
Gugigatti ...	321	768
Hindasgeri ...	332	2,337
Mandihal ...	388	468
Kadabgatti ...	91	517
Mugad ...	995	1,016
Ramapur ...	576	1,130
Kawadibail ...	302	615
Kumbarkop ...	727	1,636
Chinachi ...	638	951
Balgeri ...	446	621
Kerkop ...	449	501
Salakinkop ...	446	459
Kalkeri ...	1,244	1,543

*N.B.*—Villages where more than 300 acres are lying waste have been only selected for comparison.

The outturn of jowar, inferior millets and pulses has considerably gone down. Only paddy crop receives good attention and with all night watching a portion of this crop too is damaged. The cultivator being unable to combat the attack of wild pig has been reduced to poverty and has lost his health from night-watching in addition to his day's work. No agricultural improvement is commonly possible without a remedy against the attack of wild pig and an enclosure seems to be the best remedy though organised hunting should be the ultimate aim for its destruction.

Where stones are available within a radius of one mile I recommend a wall of the type built round the area of Mandihal village with dimensions 3' wide at the bottom and  $1\frac{1}{2}$ ' at the top and 5 feet tall. This will cost about Rs. 1,600 per running mile. Where stones are not available a pig proof wire woven fence is what is needed. At present rates the cost of this fence comes to Rs. 2,000 per running mile.

Only sugarcane cultivation may pay fencing round individual fields but for the ordinary crops one whole village or a group of villages should combine and have a common wall or fence round their area as is done at Mandihal where 874 acres have been enclosed with a stone wall at a cost of Rs. 6,500, *i.e.*, about Rs. 8 per acre which means no big

burden to the individual cultivators. Co-operative Fencing Societies of the type organised in Kalghatgi Taluka may be formed with share capital and they may approach Government for long term loans in accordance with Government Resolution No. 57-A of 4th July 1922, where needed. A joint scheme for Tegur, Hale-tegur, Guladkop, Venkatapur and Madkikop is under reference at present and plans round Mugad, Kalkeri and Devagiri are being contemplated.

With comparatively little cost the advantages of enclosure are immense and as stated below.

Cultivators will be saved from night watching which will mean good health increase in population.

*Water Supply.*—Cultivators complain that they do not receive rains as they used to get some years back and the cultivation of paddy crop with rain water alone is becoming more uncertain. They cannot grow jowar or inferior millets in rice fields for many reasons. More tanks are what are needed and the existing tanks largely need repairs. There is large scope for more individual as well as common tanks in the tract. Cultivators are poor and ignorant and what is needed is long term loan and technical advice. There is perennial brook near Hale-tegur from which water can be raised at a cheap cost and utilised with advantage. Well sinking in this tract is possible only in a few places.

*Land Improvement.*—Where cultivators have no much attack from the wild pig and have good supply of water they are generally keen on land improvement, especially on preparing rice beds by levelling the uneven land. They generally prepare their beds on contour lines and for that purpose depend upon the experienced eye of a particular man in the village for advice. In believing the eye they invariably commit mistakes and go on rectifying the same in years to follow. Technical advice with the aid of levelling instrument is what is needed.

*Manure Supply.*—Preservation of farm yard manure in the tract is very indifferent and needs attention. Much of the cowdung is wasted as fuel though there is wood in vicinity for the purpose. Cultivators hesitate to apply manure before sowing to paddy crop where it is depending only on rain water. They say it often does more harm than

good. What is needed here is a top dressing manure after impounding rice beds. Experiments with cake and ammonium sulphate are encouraging. In villages where cane is cultivated there is generally the scarcity of farm yard manure. Bone meal to paddy in these villages is also a possibility.

*Cultivation and Implements needed.*—(a) Sabul plough for breaking *mal* land and for cultivation of cane, iron scraper for levelling the land, and small rice ploughs W. K. S. and Kirloskar No. 12 are being demonstrated and have scope.

(b) Disc harrow and gallows plough will find room in big holdings with sugarcane cultivation on a large scale.

(c) Cultivation of cane in *Mallad* is yet very crude and should improve. Surface drainage, preparation of land, selection of sets, the method of planting with eyes sideways, extraction of juice with Nahan mill and gul making on Poona furnace are the principal items that are being demonstrated and have large scope for introduction.

(d) Weeding in paddy is one of the laborious and costly items especially the removal of "gonag" (a weed in drilled paddy).\*

(e) A paddy threshing machine is often a need. A bullock gear machine was tried at Dharwar and at Mandihal last season and is found to do good work. Wide demonstration will depend on future trials.

*Crops and their Varieties.*—(a) Introduction of Upland Cotton (Gadag No. 1) on *mal* lands seems to be a possibility. Results of experiments are encouraging.

(b) There is scope for groundnut and potato crops in enclosed area.

(c) A Rice Breeder at Mugad has set to work out better types of paddy by selection in local varieties.

(d) Early varieties of cane Red Sports and Manjava have given better results than local Pundia at Kambarganvi and have scope for introduction in this tract where supply of water is limited. Red Mauritius cane is another variety considered to be suited to *Mallad* and its cultivation should

\* I have written a note on the subject, Departmental Bulletin No. 107 of 1921.

extend. Cane in *Mallad* generally suffers from water logging during rains and from drought later. The above three varieties have been observed to stand both these conditions better than local *Pundia*, and hence deserve further trials.

(e) Mango grafts can be planted in red and *mal* lands where water is available.

*Diseases.*—Smut occurs in jowar crop and copper sulphate packets should be distributed with demonstrations of right use of the stuff.

*Cattle—Improvement and Scope for Breeding.*—Cultivators complain that both number and condition of cattle are falling down. From the study of records and personal observations during the past few years I am not inclined to believe the first part of the statement while I agree with the latter half. With the increase in the extent of waste lands and with high prices for cattle, there has been a tendency to increase the number of cattle. There is ample grazing during rains and cultivators are tempted to keep more than what they can afford to feed during summer. In fact the cattle feast during rains but fast during summer. Cultivation of *mal* land crops, *viz.*, *jowar* inferior millets and *kulthi* and that of second crop after paddy are declining. The supply of paddy straw alone is not sufficient and nutritious to keep up the condition of cattle throughout the year. Much of the grass is not cut but is wasted at present. If cut when flowering and stacked or turned into silage it will no doubt add to the stock of fodder. The spear grass which is grown in the tract alone, however, is not sufficiently nutritious to improve the condition of cattle. This is required to be supplemented by jowar fodder or that of inferior millets and chaff of *kulthi* and other pulse crops besides a small ration of concentrated feed to milking cows and young stock. What is required is mixed farming.

Breeding is also very indifferent in the tract. Cultivators usually separate good bull calves from the herd, rear them separately with some extra care and sell them at their breeding age to the cultivators who generally come from outside the tract and pay comparatively better price. The herd of cows has invariably poor mongrels to serve and the results are very poor as could be expected. Introduction of pure Mysore strain seems to be advisable as judged from the results on Tegur Farm. For systematic breeding and feeding

by raising the required quantity of fodder for summer, cattle farms with mixed farming are what are needed and there is large scope for opening them in this tract. These are my personal views based on experience of Tegur Farm. The young stock on hand available for observations will show what improvement we can achieve from local cows and Mysore bull and with fodder that can be raised there. Cattle farms should be encouraged in the tract with needed help. Economic management is yet a study but seems possible. The breeders may devote more attention to breeding than rearing. The bull calves when they attain the age of two may be sold to Gadnad cultivators for rearing who have got more and better fodder supply. Good bull calves get fancy prices.

*Co-operation needed for Agricultural Development.*—(a) Enclosure against wild pigs is a subject in which co-operation pays an important part. Ordinary dry crop lands cannot individually stand the heavy cost. Enclosure becomes very cheap and within the easy reach if co-operatively undertaken. This should be clearly explained to cultivators and a regular propaganda need be done on the matter.

(b) There is possibility of building more common tanks in the tract than individual, and the matter should receive attention.

(c) As regards supply of seed, implements and manure, I think, there is no need of forming societies in many places. Two or three for the whole tract will suffice for a few years to come. The first to start should be at Alnavar. Paddy seed free from Gonag, bone meal, oil cake and ammonium sulphate may first be stocked in preference to others.

(d) The movement of co-operative credit is very slow in this tract and needs more attention. Cultivators need money mainly for weeding and removal of *Gonag* among various operations of their cultivation. Loans should be issued more to this genuine purpose at the right time than for others. The crop grown with weeds and *Gonag* gives very little yield and soon goes out of cultivation.

(e) Cattle breeding can also be done co-operatively but for success, cattle farms of the type described are what are necessary.

(f) Co-operative rice hulling and sale has a future.

(g) There is much Government waste land in this tract which can be brought under cultivation by organised joint cultivation societies in a better way than what can be done by individuals. Three such societies are at present being worked out.

*Education needed for Agricultural Development.*—*Mallad* is a most backward country in Karnatak in point of education and *Dharwar Mallad* is not an exception. There are many reasons among which individual cattle watching and weeding in rice fields which drag boys from school to field in their very young age, are important. Co-operative cattle breeding and cattle watching will save many boys to education. During the time of weeding season the school may be held at their leisure. Direct method of teaching should as far as possible be adopted and agricultural lessons should be given. Agricultural education to adults is also very important and can be given through a series of sound lectures and demonstrations. Ignorance and illiteracy prevail throughout the tract and it is impossible to expect any development without proper education.

#### GADINAD.

This is a tract which has developed its agriculture to a certain extent within a past few years. The natural agency has worked a good deal in the matter. The strip of black soil adjoining *Mallad* which was once suffering from heavy rains is now producing good crops of *jowar* and cotton. Often it takes two crops of *udid* and then wheat or gram. New crops like potatoes and groundnut have also stepped in. The tract receives both the monsoons and the crops are more or less sure. The area under cotton has increased. The cultivator of *Gadinad* is generally better off than that of *Mallad*; but looking to the position in which he is placed he is by no means wiser. He has not improved his condition to such an extent as he ought to do. This situation is largely due to his ignorance. Needs for further developments are :—

1. *Land and its improvement.*—(a) The land is undulating and has many washings forming into nallas. Technical advice on construction of bunds on contour lines and long term loans are what are needed. There are two common schemes at Aminbhavi proper and there are many individual cultivators in the tract wanting the needed help.

(b) The land in the tract especially to the east is much affected with *hariyali*. Thousands of acres round Hebli affected with this weed is producing very little crop and deserve the attention. In villages of Aminbhavi Union also the lands are affected. In many cases the weed is likely to be eradicated by the use of iron ploughs. The District Agricultural Association, Dharwar, has kept a number of iron ploughs for hiring out and the Seed and Implement Societies at Aminbhavi and Navalur have just started the work. Many more iron ploughs are needed in the tract. Thousands of acres of land affected with *hariyali* round Hebli belong to Sardar Dadasaheb Jahagirdar of Hebli and he wishes to have a motor plough for the purpose of clearing his land. The Taluka Development Association should co-operate with him in doing the needful. With bunds and removal of *hariyali*, the tract especially that which lies between Dharwar Gadag and Dharwar Aminbhavi roads is capable of producing very good crops far better than what it is doing now.

2. *Water Supply*.—There is scope for sinking more wells especially in villages of Aminbhavi circle. Good water seems to be available within 30 feet. The same is the case at Saidapur and many other villages of the tract. The soil is excellent for raising garden crops. There is need of boring machine and long term loan for the purpose. This item should receive attention from the Taluka Development Association. Aminbhavi, Hanmanhal and Saidapur should receive prior attention. More wells in this tract mean much progress.

3. *Manure Supply*.—The supply of farm yard manure is insufficient in the tract. The method of preparing farm yard manure should receive better attention and the people of this tract should soon take to the use of night soil and preparation of poudrette. There is scope for increasing the number of cattle in the tract by rearing young calves which will help to increase the supply of farm yard manure.

4. *Cultivation and Implements needed*.—(a) The use of iron plough is made known to the people of this tract and wide use needs only more demonstrations.

(b) An implement for sowing seed especially cotton seed is a bad need. Improvement in the stand of the

crop means improvement in yield. This has attracted the attention of the Department and attempts are in progress. Surat cotton drill does better sowing than tubes behind the local drill and needs more demonstrations. Clipper drill has been demonstrated in the Aminbhavi Circle for sowing wheat and has been appreciated.

(c) The use of Disc Harrow is attracting the attention of the cultivators.

(d) Stone roller for threshing jowar and Olpad wheat thresher for threshing wheat are being demonstrated in the tract and should continue. In the villages of the Aminbhavi Union and round Harobelvadi and Hebli the use of wheat thresher has better scope than elsewhere, while stone roller has scope throughout the tract. All the above may be stocked for hire by the Aminbhavi Seed and Implement Society as funds permit.

5. *Crops and Varieties—Cotton.*—(a) Among various important crops, cotton has received the best attention of the Department and the results have been very useful to the cultivators of this tract.

Round Aminbhavi and Harobelvadi, cultivators demand Kumpta cross variety. The organization of pure seed of this variety should receive the attention of the Development Association by encouraging the seed growers in proper centres and by arranging to gin the produce of those seed growers through the Cotton Sale Society at Dharwar and stocking the seed in Aminbhavi Seed and Implement Society. Pure seed should be obtained from the Cotton staff of the Agricultural Department every year to suffice for seed growers. Dharwar No. 1 Cotton which has given good results on Dharwar Farm has drawn the attention of cultivators and deserves extension.

(b) Bansi wheat introduced at Harobelvadi has attracted the attention of cultivators and its cultivation is steadily increasing. The seed was also distributed round Aminbhavi during the last season. Maintaining the purity of seed and further extension of its cultivation deserves attention in the tract round Aminbhavi and Harobelvadi.



(c) As regards jowar, better yielding types are being worked on Dharwar Farm by selection in local varieties.

(d) There is scope for mango grafts in the red soil of the tract, especially to the west, near Dharwar, Aminbhavi, Marewad and Timmapur. There is need of opening a nursery for preparing grafts at Dharwar proper.

6. *Diseases and Remedy.*—(a) Smut on jowar is common in the tract and copper sulphate packets should be distributed with series of demonstrations every year. The packets may be stocked in all societies.

(b) Other diseases which are important are Cotton and Tur wilts and rust on wheat. Remedies on these are being worked out. Striga Lusia (*Bilichagan Kasa*) which is a parasite on jowar becomes often serious and has attracted attention of the Department. It is very difficult to eradicate this without co-operation.

7. *Cattle Improvement and Rearing.*—Cultivators of this tract purchase good draught cattle from Mysore territory. There is ample scope for rearing young bull calves. Fodder scarcity is not common in this tract and with circular chaff cutter they can save a good deal of kadabi. Many of the cultivators on my enquiry round Aminbhavi have expressed their desire to take to it if good bull calves can be secured. If breeding develops in Mallad as proposed in this note there will be enough good draught cattle to spare. A good deal of propaganda is needed on production of good draught cattle in Mallad and their rearing in Gadinad. Breeding as such in Gadinad has not much scope. Individual cultivators who have kept cows, however, can form bull-clubs but I think they will be more benefited by taking to rearing young bull calves.

8. *Co-operation required for Agricultural Improvement.*—(a) Co-operation in bunding is desirable but presents good many difficulties. Where possible it should not be lost sight of.

(b) The Seed and Implement Societies should increase in number. Various kinds of iron ploughs, wheat thresher, stone roller, Disc harrow and cotton seed should be stocked in general.

(c) Co-operative circular chaff cutters run by oil engine power seem to have scope in the tract.

(d) Co-operative sale of important produces other than cotton is also needed.

9. *Education required for Agricultural Development.*—(a) Various lectures in addition to demonstrations should be arranged to educate the minds of cultivators towards agricultural development especially on rural economy. Cultivators have a general belief that there is nothing to learn in agriculture or nothing to teach by opening the school or holding classes. The first duty of the Development Association should be to clear away this dull atmosphere through constant and impressive lectures and create a taste for agricultural development. This tract is favourably situated and I feel, such a propaganda will meet with success. When a taste is created agricultural lessons in vernacular schools and special vernacular agricultural schools and libraries will be the general need. Training classes may be held on Dharwar Farm.

*To conclude*, an analysis of the situation and needs of the taluka, will reveal, that the Development Association which has been started to develop the taluka, has two main functions to perform. One is to educate the minds of cultivators to realise their real needs and the other is to actually meet the needs, which they feel at present, through co-operation where possible. Both these functions can and need be done simultaneously

## Agricultural Problems of the Mundargi Petha in Dharwar District.

By H. B. Kulkarni, B.Ag., District Cotton Overseer, Gadag.

Mundargi Petha comprises an area of 65 square miles, with a population of 31,000 people, who are mostly agriculturists. It is situated to the extreme East of Dharwar District and is bounded by the Tungabhadra river on the South, Kappat Hills on the West, Gadag Taluka on the North and Nizam's territory on the East. The Petha can be agriculturally divided into three main parts: (1) the black soil tract to the North, (2) the red soil tract to the South and (3) the Kappat hill tract where the soil is of mixed nature.

In the first tract of black soil the land is mostly *karl* (hard and sticky). The rainfall is scanty, only about 19 inches in the year and that too falling for a short period from September to October. The land is much undulating and uneven. The cultivation of the *karl* land is almost impracticable under the present rainfall conditions. The crops raised on these and on other good lands with great difficulty and trouble, are liable to be seriously damaged by wild pigs and deer, a large number of which are found in the tract. The Toddy Nala flowing in the tract is over-grown on both the banks with the thick growth of prickly pear and toddy palms, for a length of about 12 miles. This prickly pear has already run into cultivated lands at many points. But apart from the evil effects of its invasion, it is affording a good shelter and breeding-ground for wild pigs. In addition to wild pigs, which are doing considerable damage to all cultivated crops, there are a large number of deer coming from the Nizam's territory. These damage the crops to a great extent and unlike the pigs the watchmen find it difficult to frighten them even by 'Ukhali bars.' Thus the main problems which seriously handicap cultivation are (1) *karl* nature of the soil and (2) wild pigs and deer.

The chief remedy for *karl* land lies in bunding the Nala at short distances and making it to over flow during the rains. This water should be made to spread evenly on the adjoining fields which will be then fit for sowing. When the soil is sufficiently moist for sowing, the matter of growing a crop with scanty rainfall is not a difficult thing in the case of *karl* land. The pig problem can be solved by clearing the prickly pear and thinning the toddy palms on the banks of the Toddy Nala. The deer problem seems to be rather difficult of solution. Deer proof fence may be erected wherever possible and hunting facilities generously afforded.

The red soil area grows garden crops including sugar cane and is suitable for an extensive cultivation of groundnut. Here also the wild pigs offer serious check to the cultivation. The thick growth of prickly pear and toddy palms found in village sites and on the banks of the nala affords shelter to the pigs. This is the only important problem of the red soil tract and the thorough destruction of all hiding places of pigs seems to be the most practical solution. There is in this tract good scope for extending the cultivation of groundnut and increasing the number of gardens.

These things are sure to improve the economic condition of the agriculturists who are now very poor but can only be attempted after the pig trouble is completely removed.

A beginning has been made to destroy the prickly pear of the tract. The old village site of Tambragundi with an area of 25 acres is completely covered by prickly pear. It has become the greatest nuisance as pigs and even panthers find an easy hiding place in it. The clearing of this site is now taken up by the association formed for that purpose. The association has secured a tagai loan of Rs. 4,000 and the work is got done by contract. The smaller branches are cut by scythes with long handles (Doties) and the thick ones are cut by the axe. The pear that is thus cut is heaped and afterwards burned. In this way it is hoped to destroy all prickly pear.

The Kappat hill tract is, in general, more suitable for fruit cultivation. The lands at the foot of the hills are suited for mango grafts. The valley of Doni can grow many kinds of fruit trees very well. But the cultivators of this tract are not making any serious attempts in the direction of fruit growing because they are greatly annoyed by wild pigs, deer and monkeys. The main problem of this area, therefore, is wild animals and this can be solved by the destruction of the prickly pear and suitable fencing. The monkeys, however, can be caught by trapping and transported to a distant forest. In this tract there is a large area in almost every village under reserve pasture which grows grass of good quality. These pastures can be better utilised for cattle and sheep breeding purposes.

In brief the whole of the Mundargi Petha is in bad need of protective measures against wild pigs, deer and in some places monkeys. The destruction of prickly pear and other thick growths, a pig proof fence on the western boundary a distance of 30 miles and a deer proof fence on the northern and eastern boundaries for a distance of 25 miles seem to be the chief remedy. The Petha also suffers seriously from want of sufficient rain and this can be remedied to some extent by increasing the water supply of Dambal Tank, and by bunding the Toddy and Doni Nalas. In this respect it may be mentioned here that there are good prospects of damming the Tungabhadra river on the Kappat hill which is likely to irrigate many thousands of acres in the Petha.

## The Present Cotton Situation of the Southern Maratha Country.

By V. R. Dharwarkar, M.A., Cotton Superintendent, Southern Maratha Country.

The greatest commercial crop of the Southern Maratha Country is cotton. The grain crop exceeds it in total value but the greater part of it is consumed by the growers whereas all the cotton produced is sold off. It is the chief and often almost the only source of income to a larger proportion of the farmers of the Southern Maratha Country. It is so important that low prices or any other factor which reduces the profitableness of the crop greatly disturbs the economic life of the *Rayats*. When the cotton crop is good and brings good prices the condition of *Rayats* is prosperous.

The Southern Maratha Country can be divided into the following tracts on the bases of rainfall:—

(1) The tract called *Mallad* in Dharwar, Belgaum and Kanara purely grows paddy and other cereals. It receives from 35 to 50 inches of rain per annum, and in some places a little more.

(2) *Gadinad*.—This tract borders the *Mallad* and comprises the talukas of Bankapur, Haveri, Ranebennur and  $\frac{2}{3}$  rds portion of Dharwar, Hubli Talukas of the Dharwar District and Bailhongal and  $\frac{1}{3}$  rd portion of Saundatti Taluka of the Belgaum District. In this area the rainfall is regular and there is more certainty of a normal crop of cotton. Approximately this tract has an area of about  $2\frac{1}{2}$  lakhs acres under cotton.

(3) *Yerinad*.—This includes the whole of the Kumpta Cotton area of Navalgund, and about  $\frac{1}{3}$  rd portion of Hubli Dharwar Talukas of the Dharwar District and the entire taluka of Athani,  $\frac{2}{3}$  rds of Saundatti Taluka of Belgaum District and the whole of the Bijapur District except Hungund Taluka. This also grows Dharwar-American Cotton on an area of  $2\frac{1}{2}$  lakhs acres. It includes Gadag Ron Talukas and about 10 per cent. area of Hubli and Ranebennur Talukas of the Dharwar District and the most of the Hungund Taluka of the Bijapur District. The area of Dharwar-American is intermingling with that of Kumpta area.

The rainfall in *Yerinad* is much smaller and more uncertain as one proceeds to the east. The rains of August

and September are more certain and hence the people mainly rely on rabi crops.

With these preliminary remarks I beg to place before the reader a comparative situation. Before the year 1905 we found only two kinds of cotton grown in the Southern Maratha Country, *viz.*, Kumpta (*Javari Hatti*) and sawgin (*Vilayati* or *Dolahatti*). Since the establishment of the Agricultural Department in this Division trials were made in introducing new varieties such as Broach and Cambodia. These introduced cottons, though meant to replace the local cotton had a very limited spread. The maximum area grown under Broach and Cambodia came to about 6,000 and 12,000 acres respectively against the total average area of 12 lakhs of Kumpta and about 2½ lakhs of sawgin. As it was found that these newly put up cottons were not spreading, more attention was given to selection in local varieties since the year 1913. As a result of this selection we have Dharwar No. I (Kumpta selected) and Gadag No. I (upland), which have greater possibilities of replacing the ordinary cottons grown now. The characteristic and nature of these cottons have already been described in last year's year book on page 33.

*Extent of Area.*—Rapid spread of these new types began since the year 1918. In order to ascertain their superiority over ordinary cottons, comparative trials were taken up in various places of the Division and crop demonstrations were held year after year. Enthusiastic landlords interested in improvement of agriculture were supplied with these seeds for trial. By the above methods sufficiently large quantity of Kapas of Dharwar No. I and Gadag No. I was available for sale both at Hubli and Gadag in the year 1918. The premiums realised in the auctions of that year, *viz.*, Rs. 15 and 40 on an average per Naga for Dharwar No. I and Gadag No. I respectively, gave a very good impetus to the rapid spread of these two cottons. The following statement gives a progressive situation of acreage under these types:—

Year.	Kind of cotton and approximate area in acres.		Remarks.
	Dharwar No. I.	Gadag No. I.	
1919-20	Acres 4,320	Acres. 2,230	
1920-21	5,264	8,053	
1921-22	28,500	34,000	
1922-23	88,980	45,466	

The areas in the above statement were all sown from the seed supplied by the Agricultural Department and the Co-operative Seed Agencies. Equally large area was, however, grown from the seed distributed by other agencies.

Arrangement of seed supply and the maintenance of purity is being carried on in accordance with a definite scheme described on page 48 of the last year's year book. In the rapid extension of area under these types, the Co-operative and Seed Societies play a very important part. As already described the seed produced of 5,000 acres of each is bought by these bodies for general distribution.

*Seed Supply.*—Formerly the cotton growers were in the habit of keeping their own seed for sowing purposes by ginning the kapas of 1st picking through small hand gins and foot-roller gins. Now the cultivators almost entirely depend upon the power gin for their seed and as the latter handle good and bad kapas together the seed thus obtained contains a large amount of poor and invariably mixed seed of inferior quality. The Co-operative Societies now supply reliable seed. They purchase pure kapas and gin it under their supervision. The seed thus obtained is passed through the sieves specially devised to remove the small and the shrivelled which are useless for sowing. Every Seed Distributing Agency now adopts this procedure. By this process it is found that about 80 per-cent. of seeds germinate. The ideal, easy and inexpensive method for securing almost cent. per cent. germination, is being demonstrated since the last two years. This process is described in Leaflet No. 3 of 1917, Bombay Department of Agriculture. In this method seeds are immersed in salt water solution which separates good seeds. Cultivators are, however, slow in adopting this method. They find that the seeds stocked by the Co-operative Sale and Seed Societies after passing through the sieves is quite good.

In the beginning the Agricultural Department opened some depots of seeds of improved types of cotton and advised Sale Societies to stock seeds. As the demand began to increase, it was found advisable to stock seeds in various centres of cotton growing tracts. Almost all Seed Societies which were formerly stocking ordinary seed, are now giving large indents for improved kinds of

cotton seeds. The following statement gives a general idea of location of various depots now in existence:—

Name of central depot.	No. of Sub-depots.	Kind of seed stocked.		
		Dharwar No. 1.	Gadag No. 1.	Dharwar No. 3.
		lbs.	lbs.	lbs.
Hubli ...	11	431,202	69,402	1,830
Dharwar ...	3	...	...	52,000.
Gadag ...	10	49,560	363,793'	...
Haveri ...	7	63,000	...	...
Savanur ...	1	65,300	...	...
Bijapur District ...	3	...	21,000 kharif.	...
Do. ...	5	18,000	7,000	...
Belgaum District ...	2	3,500	...	%
Total ...	42	630,262	461,195	59,830

These 42 sub-depots include the Seed Societies and the special depots opened by the Sale Societies. The work of seed distribution is rapidly increasing. All this seed is from the reliable origin.

As already stated experiments are undertaken in cultivators' fields to ascertain the advantages of the improved cottons in different parts of the tract. The following statement gives the results of these experiments. They indicate that the improved cottons have an advantage over the local cotton all over the tract:—

Serial No.	Name of place.	Yield per acre.		Remarks.
		Dharwar 1.	Kumpta ordinary.	
		lbs.	lbs.	
1	Amminbhavi ...	226	201	Average of 3 years.
2	Unatal ...	242	221	Do.
3	Haveri ...	358	322	Do.
4	Shiggaon ...	483	439	Do.
5	Navalgund ...	180	185	Average of 4 years.
6	Bagalkot ...	136	184	Do.
7	Alur ...	126	137	Average of 3 years.
8	Saundatti ...	292	278	Average of 2 years.
9	Manguli ...	335	296	Do.
10	Bailhongal ...	143	201	Do.



Serial No.	Name of place.	Yield per acre.		Remarks.
		Gadag No. 1.	D. A. Ordinary.	
1	Kurtakoti ...	lbs. 174	lbs. 168	1922
2	Sudi ...	146	145	1922
3	Hungund ...	175	170	1922
4	Gadag Farm ...	466	890	Average of 6 years.

From the above statement it is seen that Dharwar No. I in all places except Navalgund and Alur has beaten down the ordinary Kūmpta. The figures of Alur and Navalgund though go in favour of ordinary, still the value of yield per acre of Dharwar No. I, is higher than the ordinary.

At Bailhongal, Dharwar No. 3 has given more yields. As regards Gadag No. I (Upland) the results of one year only are available.

With the above figures as they stand, due efforts for the rapid spread of these two cottons are to be made by the distributing and the propaganda bodies like Taluka Development Associations.

The whole of *Gadinad* except a small red soil area which grows *mungari* (kharif) Dharwar American Cotton, can be replaced by Dharwar No. I Cotton. In place of American, Gadag No. I can be substituted with advantage.

In *Yerinad* especially the talukas of Navalgund, Athani, Saundatti, Bagalkot, Bagewadi are almost purely Kūmpta type area. Attempt in growing Gadag No. I, here have failed. The Dharwar American area of Gadag, Ron, Hungund and Muddebihal Talukas are quite suited for Gadag No. I.

In Sindgi Taluka *mungari* (kharif) crop of Gadag No. I in bunded fields is giving very excellent crops. In the Bijapur District where such facility is available a *mungari* crop of Gadag No. I is recommended.

At Bijapur proper and in Indi Taluka where irrigation facilities are available a kharif crop of Gadag No. I can be grown with profit. There is an area of about 300 acres in Indi Taluka under N. R. (Khandesh) grown with 2 or 3

irrigations. Experimental trials taken go in favour of Gadag No. I. At Bijapur, Gadag No. I gives 1,150 lbs. of yield per acre.

Especially the Bijapur District had failure of August-September rains since last 3 years. Even cotton sowing of Kumpta type was done as a compulsory measure after the 2nd week of October with very bad results. From general observations one can suggest that Kumpta type of cotton in the Bijapur Kumpta area might be sown up to the middle of September with advantage. If this opportunity is not available, it is observed that Gadag No. I sown after the middle of September but not later the middle of October has given better results than Kumpta. If timely rains fall, it is better to sow Kumpta type of cotton in this area.

*General Cultivation Practices.*—Time and method of preparing land, of sowing, picking the cotton and packing in gunnies for the market vary according to different tracts. Sowing of cotton through seed bowls is more economical than the local method of sowing the seeds through tubes. In the former the seed is regularly fed and is deposited at a uniform depth in the soil. In the local method, owing to the intermittent feeding of seed having only one spare hand for the purpose, there are usually irregular long blanks to be seen in every cotton row. Though newly introduced method of sowing through bowl is not an ideal one, the method advised is better one in the absence of a typical drill. Demonstration of this kind of drills is being carried on in every cotton centre with a good success. In Haveri Taluka this method is extending to greater extent.

*Cotton Diseases.*—Red-leaf blight appears very often in Dharwar American Cotton causing considerable damage to the crop. The most effective method now advertised is the substitution of Gadag No. I Cotton in place of Dharwar American. This resists the attack to a remarkable extent.

Cotton wilt is a disease which causes stunting, wilting and death of the entire plant. This is due to a fungus (*Fusarium*) which enters the roots and plugs the water vessels. Thus fungus remains in the soil so that infested fields give very poor yields. The remedy chiefly lies in growing resistant types (page 15). A special staff has been appointed at Dharwar to investigate this problem.

*Marketing.*—Though producers are more or less at the mercy of the consumers with regard to price, they can exercise considerable control over the prices by selling their produce through co-operative sales organisations which are now established in principal centres of the Southern Maratha Country. The method of marketing through such agencies and its advantages have already been described on page 46 of the last year's year book. The total number of Dokaras sold through Co-operative Sale Societies was, 17,493 of different types of cotton graded according to quality and lint outturn and a premium of Rs. 1,22,281 was realised by the producers.

The grading helps the buyers in giving proper prices. In addition to grading we do the spinning test of the improved cottons and the results of these tests are supplied to the buyers.

Another important item of improving the quality of kapas taken up in hand is the clean picking propaganda work. The aim is to reduce the heavy loss in blow room as much as we can. This was arranged by series of lectures in the group of villages round about Hubli with a result that there were 200 bales of clean picked cotton for sale. The consumers on their part offered very encouraging prices in order to induce the cotton growers to take up to clean picking method.

The statement below gives the idea of extra price realised by clean picking :—

Kind of Kapas.	No. of Dokaras.	Price realised for 1st class.	Price realised for clean class.
		Rs.	Rs.
Dharwar No. I	170	325	351
Gadag No. I	250	360	385
Navasari	155	370	400

## A Note on Co-operative Sale of Agricultural Produce.

By M. A. Shetti, B. Ag., Agricultural Organiser, Co-operative Societies,  
Southern Division.

It is a well known fact that our agriculturists are very backward in education and lack very much in business capacity, consequently they lose every year at least 25 per cent. of their agricultural income in disposing off their produce. So it is found that the co-operative sale is the best remedy to minimise the loss thus caused to the cultivators. Co-operative agricultural credit movement has developed to a considerable extent in Southern Division but efforts are now being made to develop the non-credit agricultural movement and success has been achieved to a certain extent already specially in co-operative sale.

Cotton is one of the important crops in Southern Division and generally cultivators are losing to a great extent in disposing off this produce. About 10 years ago when Broach and Cambodia Cottons were introduced in the Southern Division they did not fetch proper prices. Hence in order to get proper prices Agricultural Department organised auction sales and it was found by experience that very good prices were realised in these auction sales. It was then thought advisable that the people themselves should manage these things and consequently Co-operative Cotton Sale Societies are now organised in suitable centres.

Seven Co-operative Cotton Sale Societies are started in Southern Division at present. Gadag and Hubli are the important cotton markets in Dharwar District and consequently Sale Societies in these two places are in a very prospering condition.

The following statement gives the details of work of each society in this Division :—

Serial No.	Name of society.	Area of operation.	Share capital.	Number of members.	No. of Dokras sold, 1922-23.	Value of cotton sold.	Remarks.
1	Dharwar ...	Dharwar Taluka and a portion of Navalgund.	2,900	150	1,400	Rs. 76,000	
2	Hubli ...	Hubli, Bankapur, Kalghatgi and a portion of Navalgund.	6,000	1,200	13,000	8,72,000	
	Carried over ...	...	...	...	14,400	9,48,000	

Serial No.	Name of society.	Area of operation.	Share capital.	Number of members.	No. of bales sold 1922-23.	Value of cotton sold.	Remarks.
		Brought forward			14,400	9,48,000	
3	Gadag ...	Gadag, Navalgund, Ron	15,000	1,200	7,400	5,20,000	
4	Annigeri ...	Annigeri and round about villages.	1,900	130	700	56,000	
5	Bagalkot ...	Bagalkot, Hungund and Muddebihal.	2,000	140	700	56,000	
6	Haveri ...	Haveri and portion of Bankapur and Kod Talukas.	4,000	110	1,600	1,17,000	
7	Bailhongal	Bailhongal and Savadatti.	1,200	100	2,200	1,48,000	
		Total ...	...	...	27,000	18,45,000	

Dharwar Sale Society mainly deals with (Kumpta cross) Dharwar No. 3 Cotton, and has taken up distribution of seed of that type.

Hubli and Gadag, mainly deal with Dharwar No. 1 and Gadag No. 1 Cottons respectively and are doing very good propaganda work with regard to extension of these types on larger scales by opening seed depots in suitable centres.

Kapas at these places is graded according to ginning outturn and cleanliness and offered for sale. Auction sale dates are notified with the approximate quantity available for sale.

The business done by the above Sale Societies is yet small as compared with the total quantity of cotton produced in the tract. For developing them further the following measures are under consideration:—

- (1) Small cotton markets do not attract sufficient number of buyers. There are only two big cotton markets in Karnatak one at Hubli for Kumpta Cotton and another at Gadag for Dharwar American Cotton. Instead of starting a number of independent Sale Societies at different places it is better to organise two unions at the above market cities and have a number of societies

in the country for collecting and grading the kapas. The unions will then help the societies to sell their kapas by auctioning the samples.

(2) It is found that the Credit Societies are not financing the members adequately with a view to encourage them to sell their cotton through the Sale Societies. The remedy seems to be in bringing the Credit Societies, Sale Societies and the Central Bank into closer contact and this is being done.

(3) Sale Societies now entirely depend for grading their kapas on hired gins the latter are not available in time and this often causes great inconvenience and loss. Hubli and Gadag Sale Societies are therefore contemplating to have their own gin for the purpose.

In addition to the above mentioned Cotton Sale Societies there are other types of Sale Societies in Southern Division, such as Co-operative Chilly Sale Society, Byadgi and Co-operative Tobacco Sale Society at Nipani.

#### BYADGI CO-OPERATIVE CHILLY SALE SOCIETY.

This society was registered in 1921 and is doing good business since its registration. It has collected Rs. 2,400 as share capital and has got Rs. 722-6-0 as reserve fund, the number of members is 127 for the present. It has sold during this year about 2,500 Dokras of chillies, *i.e.*, 4,900 maunds worth Rs. 39,500 and has earned Rs. 1,000 as commission. Auction sale was arranged but it was not a success but efforts will have to be made again to make the auction sale a success.

#### NIPANI CO-OPERATIVE TOBACCO SALE SOCIETY.

This society was registered only during the month of March 1922 and it has made an excellent beginning. It has already collected Rs. 1,800 as share capital. It has got a very good scope and is likely to be a successful society.

Several other types of Sale Societies are to be started in Southern Division, *e.g.*, Betel Leave Sale Society is to be started at Hattimattur and Co-operative Rice Sale Society at Alur and Kittur.

## RIDGE CULTIVATION IN LOWER GUJARAT.

Gujarat\* consists essentially of a flat plain lying almost at sea level, stretching between the sea and various mountain ranges, from a hundred miles north of Bombay, northward to the fringe of the Rajputana desert. In the south of this region, generally known as Lower Gujarat, the general aspect, especially of the portion where cotton and *jowar* (*Andropogon sorghum*) are chiefly grown, is that of a flat plain formed by the alluvium deposited in the basins of the Tapti, Nerbudda and some other rivers. Of this area, Surat may perhaps be regarded as the most typical centre. The soil in it, being derived from the region of the Deccan trap, has all the characteristics of the black cotton soil or *regur* of Western India, varying in depth and stiffness, however, from place to place.

This black soil possesses in this region, in a pre-eminent degree, the power of expansion and contraction on wetting and drying respectively, which is the most obvious character of black cotton soil. As a result, in the hot weather, it is traversed by deep and wide cracks which disappear with the first advent of the rains. The cracking of the soil is considered by the people to be a great advantage as it leads to the surface soil being mixed with the subsoil either during the process of cultivation or during the first rains. The flow of the water into the cracks, carrying with it a large amount of surface soil, leads, on the one hand, to a capacity on the part of the soil to absorb when perfectly dry, a very large amount of rain (even up to seven to eight inches) in one continuous fall without surface wash or erosion, and (when cultivation is on the flat) to the conversion of a field into a series of basins (especially if the previous crop is a deep rooted one) which need to be levelled up before any further operation is undertaken. Though the soil at the first monsoon rain is capable of absorbing an enormous amount of water, once the cracks are filled up and the soil saturated, the water drains away so slowly, that the land remains very full of water for a long time and it can only absorb further water with difficulty.

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\* The general description of the soil conditions prevailing in South and Lower Gujarat has been very largely summarised and adapted from M. L. Patel's recent Memoir, "Studies in Gujarat Cottons", Part II (Memoirs, Department of Agriculture, India, Bot. Ser. Vol. XII, No. 5 of 1924).

If the rain remains continuous and heavy, erosion takes place, water stagnates on the surface, and all the signs of temporary water-logging are seen.

In this area the rainfall is also of a character which tends to emphasise the characteristics of the soil which have just been described. The rainfall is usually forty inches or over per annum, but this is concentrated in five months, the rest of the year being entirely dry. The actual average rainfall for forty-four years at Surat and at Jalalpur (Navsari), two typical centres, is as follows:—

Month.	Surat. Inches.	Jalalpur (Navsari) Inches.
January	...	...
February	...	...
March	...	...
April	...	...
May	...	...
June	8.48	9.33
July	16.69	21.27
August	7.76	9.45
September	6.14	8.07
October	1.65	1.86
November	...	...
December	...	...
Total	40.72	49.98

Though this rain is exceedingly variable, its general character is such as to give, in by far the largest proportions of cases, a very large rainfall in July, which makes it almost certain that at this time of the year any crop on the ground will be subjected, when cultivation is on the flat, to a partial water-logging during part of that month and possibly also in June and August, which may include partial flooding, at intervals, for days together.

In spite of these facts, the ordinary cultivation of this area consists of a rotation of *jowar* (*Andropogon sorghum*) and cotton, grown on the flat, and sown as soon after the commencement of the rains in June as the soil conditions allow. The ordinary procedure is that the preparatory tillage for the crop to be grown begins about the end of April by the harrowing of the fields to remove the stubbles of the previous crop. If manure is used in the rotation it is usually applied in May or June, previous to the cotton crop, but consists exclusively of cattle manure. Artificial manures have



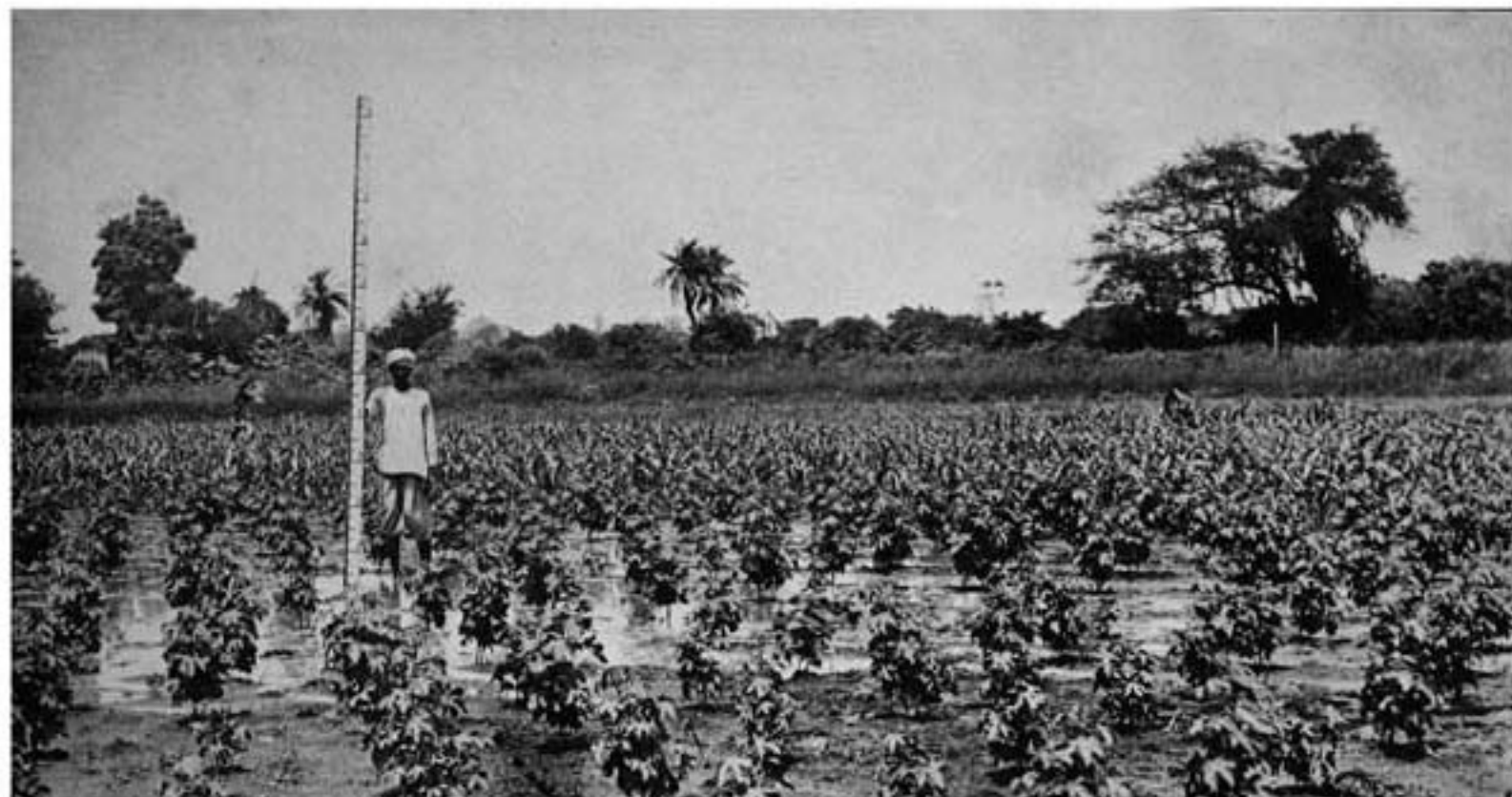


PLATE 1.—Showing Oversaturation and Stagnation of Black Soil after good Rains from 17th to 20th September 1922, of nearly 6" of Rain.

never been used, hitherto, on any large scale. When the rain comes, the fall is usually heavy and is followed by a break, during which the land is ploughed, harrowed, and sown with great speed, for if further rain comes, the land can neither be worked nor sown until it is again partially dry.

After sowing, the crops may fail owing to excessive rain or owing (more exceptionally) to drought, and in this case sowing has to be repeated. If there is no actual failure and the usual heavy rain takes place in July, there ensues a period during which both *jowar* and cotton become yellow, look miserable, and have every appearance of lack of root aeration or water-logging (Plate 1).

The usual remedy for this state of affairs would normally be considered to be either under-drainage or ridge cultivation. But under-drainage with tiles is impossible in the conditions of real black cotton soil which dries completely out during part of the year, as the cracking of the soil (as has often been found) tears the tiles apart, and they rapidly cease to form a drain. Open drains are of little value, as, owing to the slimy and treacherous character of the soil, they are very difficult to keep open. Further, owing to its very great retentive powers for water, drainage from such a partly water-logged soil is very slow, and hence the number of open drains required is impossibly large.

On the other hand, ridge cultivation using small ridges such as can be turned up by a country wooden plough is not feasible, for, again owing to the slimy and treacherous character of the soil, these small ridges tend to disappear during a spell of heavy rain in July, and the use of such small ridges has again and again been proved to be of small value.

As a result of these facts, cultivation on the flat without drains has remained universal in the black soils of Lower Gujarat, though it has always been recognised that the less slimy and retentive soils give much better and more reliable returns than the others, and though in considerable areas (Olpad, &c.) the partial water-logging above referred to has been so long continued that cultivation has been so risky as to make the land hardly capable of being cultivated.

Moreover, the considerations referred to would seem to be almost the dominant factor in the yield, and modifications of cultivation or of manuring or of rotation, which do not deal with this question of partial water-logging, seem very ineffective in producing any increases in yield of the main crops of

the area. The experience on the Surat Government Farm\* from the year 1902 to 1920 was that no method was effective in materially increasing the yield of these crops, provided flat cultivation was retained. During the early years of that farm, the effect of deeper and more perfect cultivation was fully studied, and no appreciable advantage was found. In several other series of experiments the introduction of a leguminous crop [tuver (*Cajanus indicus*), groundnut, &c.,] was studied, again without material effect on the yield of the main crops. Then attention was concentrated on the judicious use of cattle manure or of artificial manures, but with most disappointing results, for the manures did not by any means always produce increases in yield, and, when they did, the application was rarely profitable. In one case only when a very large amount (85 cart-loads per acre) of crude night soil or a corresponding large amount of cattle manure was applied, was a large increase of yield constantly obtained, the increase being maintained for a number of years, owing largely, it is probable, to an alteration in the physical texture of the soil.

#### First Experiments on Ridge Cultivation.

Under these circumstances, it was decided to try and see whether the use of much larger and higher ridges was possible, and whether under these conditions manuring could by some means or other be made effective. A preliminary comparison was made in 1920-21 between the crops raised on the ordinary flat cultivation of the Government Farm without manure, and the crops raised on ridges either ten or fourteen inches high made with a large ridging plough, the seed being dibbled on the top of the ridges in one row as soon as the weather allowed. The ridged plots were manured, in 1920-21 only, with 50 cart-loads of cattle manure per acre before ploughing or ridging, and in addition the following applications were made per acre after ridging, *in the furrow between the ridges*:—

- (1) In June at planting—
  - 2,000 lb. cotton seed hulls.
  - 300 lb. slaked lime.
  - 300 lb. wood ashes.

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\* The figures of the results referred to will be found in the Annual Reports of the Surat Farm from 1902 to date.

## (2) In September—

400 lb. cotton seed meal.

1,000 lb. ground rock phosphate.

The application of these manures in the ridged plots reduced the value of any comparison which can be made between the ridged and flat plots, but as many previous experiments had shown little result from these quantities of manure when applied without ridging, and as the experiment was only preliminary, the results may be given.

*Cotton.*—Ridges made in 1920-21, 14 inches high Ridges six feet apart. Variety of cotton used, *Broach Desh Strain—1 A Long Boll.*

Treatment.	Spacing.	Yield (by plots) of seed cotton per acre.	Average yield of seed cotton per acre.
<i>1920-21.</i>		lb.	lb.
(1) Flat plot, no manure	Dibbled 2 ft. by 2 ft.	(a) 484 (b) 479	481
(2) Flat plot, no manure.	Dibbled 3 ft. by 3 ft.	(a) 645 (b) 627	636
(3) Ridged, single line of plants on each ridge.	Dibbled plants 1½ ft. apart.	(a) 795 (b) 832	814
(4) Ridged, single line of plants on each ridge.	Dibbled plants 3 ft. apart.	(a) 857 (b) 887	872
<i>1921-22.</i>			
(1) Flat plot, no manure.	Dibbled 2 ft. by 2 ft.	(a) 425 (b) 410	417
(2) Flat plot, no manure.	Dibbled 3 ft. by 3 ft.	(a) 450 (b) 426	438
(3) Ridged, single line of plants on each ridge.	Dibbled plants 1½ ft. apart.	(a) 538 (b) 515	526
(4) Ridged, single line of plants on each ridge.	Dibbled plants 3 ft. apart.	(a) 454 (b) 537	495

The effect of the ridging and treatment which accompanies is remarkable. (Plates 2, 3). While it has been difficult in the past with the ordinary type of cotton grown and without irrigation to get more than 600 lb. of seed cotton per acre, the year has jumped in the first year after ridging to between 800 and 900 lb. per acre. Without any further treatment the crop in the following year is also much higher than on the flat. Taking the best of the flat plots (spaced three feet by three feet) as the basis, we have the following results in summary:—

Treatment.	Average yield of cotton per acre.	Percentage increase in yield.
<i>1920-21.</i>		
(1) Flat plot ...	636	...
(2) Ridged, close planting ...	814	28
(3) Ridged, wide planting ...	872	37
<i>1921-22.</i>		
(1) Flat plot ...	438	...
(2) Ridged, close planting ...	525	20
(3) Ridged, wide planting ...	495	13

This result was in part due to better growth of the plants, but also partly to the larger number of gaps in the flat plots. These gaps represent the normal loss due to failure in the semi water-logged soil. The actual percentage of gaps in the three plots named above (obtained by counting in a few rows taken at random) was as follows:

	1920-21. Percentage of gaps.	1921-22. Percentage of gaps.
	Per cent.	Per cent.
(1) Flat plot ...	19	14
(2) Ridged, close planting ...	10½	6
(3) Ridged, wide planting ...	5½	2½



**PLATE 2.**—Showing Profuse Drainage and Storing of Water in the Furrow after nearly 6" of Rain from 17th to 20th September 1922.



PLATE 3.—Showing Profuse Drainage and Storing of Water in the Furrow after nearly 6" of Rain from 17th to 20th September 1922.

*Jowar*.—Ridges made in 1920-21, ten inches high. Ridges four feet apart. Ridges made in 1921-22, 14 inches high. Ridges six feet apart. Variety of *jowar* used *Perio*.

Treatment.	Spacing.	Yield by plots per acre.		Average yield per acre.	
		Grain.	Straw, &c.	Grain.	Straw, &c.
		lb.	lb.	lb.	lb.
<i>1920-21.</i>					
(1) Flat plot, no manure.	Drilled, 2 ft. rows, 1 ft. apart in row.	{ a 820 b 870 }	{ 3,130 2,830 }	845	2,990
(2) Flat plot, no manure.	Dibbled 3 ft. by 3 ft.	{ a 1,145 b 1,190 }	{ 3,807 4,677 }	1,167	4,240
(3) Ridged single line of plants per ridge.	Dibbled 1 ft. apart (one plant per dibble).	{ a 1,150 b 1,165 }	{ 3,100 3,150 }	1,157	3,125
(4) Ridged, single line of plants per ridge.	Dibbled 1 ft. apart (5 plants per dibble).	{ a 1,130 b 1,050 }	{ 3,320 3,185 }	1,090	3,250
<i>1921-22.</i>					
(1) Flat plot, no manure.	Drilled, 2 ft. rows, 1 ft. apart in rows.	{ a 945 b 900 }	{ 1,600 1,465 }	922	1,532
(2) Flat plot, no manure (Plate 4).	Drilled, 3 ft. rows, 1 ft. apart in rows.	{ a 945 b 960 }	{ 1,630 1,770 }	952	1,700
(3) Ridged, double lines of plants on ridges.	Drilled, 9 inches apart in rows 2 feet apart.	{ a 1,340 b 1,475 }	{ 3,280 3,385 }	1,407	3,332
(4) Ridged, double line of plants on ridges (Plate 5):	Drilled, 18 inches apart in rows 2 feet apart.	{ a 1,635 b 1,517 }	{ 3,865 3,600 }	1,576	3,732



In the case of *jowar* little or no effect is visible in 1920-21 even with the heavy manuring given to the ridged plots; on the other hand the effect in 1921-22 even without any further manuring is remarkable. *Jowar* is a relatively shallow crop, and would naturally suffer badly from the partial water-logging in a wet year. Now 1921-22 was such a wet year in July, though there was no heavy rain in June, while 1920-21 gave at no time such a heavy and continuous downpour. The actual rainfall per fortnight in the two years was as follows:—

		Rainfall.	
		1920.	1921.
		Inches.	Inches.
June—1st fortnight	...	7.14	0.41
2nd fortnight	...	0.62	0.40
July—1st fortnight	...	6.20	2.29
2nd fortnight	...	4.31	25.18
August—1st fortnight	...	3.12	5.02
2nd fortnight	...	1.39	2.94

#### Further Experiments on Ridging.

The results just quoted give a clear indication that we have discovered one of the chief causes of the limitation of yield and the lack of effectiveness of manures at Surat and in the black cotton soil of Gujarat generally. An experiment was, however, laid out under more rigid conditions by which—

(1) the general effect of ridging on the cotton and *jowar* plants and on their yield could be determined;

(2) the effect of manures on such ridged crops, and the best way of applying it;

(3) the best manner of applying interculture during the growth of the crop.

In this case all ridges, made during the hot weather before the crops were sown, were constructed 14 inches high and five feet apart between the centres of the ridges. The ridges themselves had a flat top 18 inches wide, and the

furrows were wide enough to allow the passage of a plough at the bottom for deep interculture purposes.

All planting, both on the flat and on the ridged plots, was done with the same spacing. Cotton was dibbled in at five feet between the rows, and two feet between the plants in the rows. *Jowar* was drilled in two adjacent rows, 18 inches apart on the ridges, and at a corresponding distance on the flat.

The experiment was in two sections. The first was to determine the effect of ridging without manure whether accompanied by shallow or deep inter-tillage between the ridges, as soon as the condition of the soil allowed this to be done, the second was to ascertain the effect of manure in ridged plots and the best method of applying it.

### 1ST EXPERIMENT.

#### *Ridging without Manure.*

*Cotton (Broach Deshi, Strain 1027 A. L. F.).*

Treatment.	1922-23, Seed cotton yield per acre.	1923-24, Seed cotton yield per acre.	Average, Seed cotton yield per acre.	Increased yield over flat plot.
	lb.	lb.	lb.	Per cent.
(1) Flat with usual inter-tillage.	534	471	502	0
(2) Ridged, with shallow inter-tillage.	616	542	579	15
(3) Ridged with deep inter-tillage.	660	575	617	23

#### *Jowar (Perio).*

Treatment.	1922-23, Yield per acre.		1923-24, Yield per acre.		Yield per acre Average.		Increased yield over flat.	
	Grain.	Fodder.	Grain.	Fodder.	Grain.	Fodder.	Grain.	Fodder.
	lb.	lb.	lb.	lb.	lb.	lb.	Per cent.	Per cent.
(1) Flat with usual inter-tillage.	880	1,635	777	1,632	828	1,633	...	...
(2) Ridged with shallow inter-tillage.	933	1,846	896	1,547	914	1,696	11	7
(3) Ridged with deep inter-tillage.	1,055	2,167	983	1,422	1,019	1,794	23	10

When account is taken of the fact that 1922 was a wet year and that 1923 was a very dry year, the success of ridging is considerable even when unaccompanied by manuring, but to get the full advantage of it, inter-tillage must be done deeply in the furrows between the ridges. If this is carried out an increase of yield of seed cotton and of *jowar* grain amounting to 23 per cent. may be expected, with a ten per cent. increase in the *yield* of *jowar* fodder (including chaff).

This is accompanied by a greater development of the plants both above and below ground. So far as the roots are concerned two typical cotton plants grown on the flat and on the ridged land with deep inter-tillage were completely excavated in 1922, and the roots gave the following measurements:—

	Roots on Flat Plot.	Roots on Ridged Plot.	Increase.
	Inches.	Inches.	Per cent.
(1) Total length of main root branches.	272	686	152
(2) Vertical depth of main root branches—			
(a) Greatest depth ...	33	41	24
(b) Average depth ...	32	33	...
(3) Range of main root branches from main stem—			
(a) Greatest range ...	47	60	28
(b) Average range ...	29	29	...

The increase of yield of seed cotton on the ridged plot amounting to 24 per cent. corresponds, therefore, with an increase in root development evidently caused by the growth in the early stages unimpeded by water-logging and by the deep intertillage between the furrows, which allowed the roots to spread out without difficulty in the later stages.

The growth, above ground, on the ridged plot showed also a larger development of flower buds. The total number

of flower buds on a plot of one-tenth acre was as follows (based on examination of one hundred plants):--

	Number of flower buds.	Increase over flat plot per cent.
(1) Flat, with usual inter-tillage	97,600	...
(2) Ridged, with shallow inter-tillage	108,200	11
(3) Ridged, with deep inter-tillage	113,350	16

So far the figures given are from the crops of 1922-23 and 1923-24. The records for these plots were, however, continued for 1924-25 which was an excellent season for growth and gave figures as follows:—

#### 1ST EXPERIMENT.

##### *Ridging without Manure.*

*Cotton (Broach Deshi, Strain 1027 A. L. F.).*

Treatment.	1924-25, Seed cotton yield per acre.	Increased yield over flat plot per cent.
	lb.	Per cent.
(1) Flat, with usual inter-tillage	800	...
(2) Ridged, with shallow inter-tillage.	875	9½
(3) Ridged, with deep inter-tillage	1,006	26

##### *Jowar (Perio).*

Treatment.	1924-25, Yield per acre.		Increased yield over flat plot.	
	Grain.	Fodder.	Grain.	Fodder.
	lb.	lb.	Per cent.	Per cent.
(1) Flat, with usual inter-tillage.	817	2,110	...	...
(2) Ridged, with shallow inter-tillage.	970	2,317	19	10
(3) Ridged, with deep inter-tillage.	1,097	2,210	34	5

We have thus, in what was recognised as a very good season without manure, got an exceptionally high yield of cotton on all the plots, but the ridges have still had a very similar effect from that of the previous years, and the ridges combined with deep inter-tillage have given an increase of 26 per cent. of *kapas* as compared with the flat plot. In the case of *jowar*, again without manure, but with more efficient inter-tillage than in the previous years by means of the middle Buster (*see* page 23) an increase of 34 per cent. of grain was found with ridging and deep inter-tillage. The fodder increased less but the present result agrees with those previously recorded.

We have, therefore, evidence from every point of view that ridging the land in the manner described brings about improved development of the plants resulting in a larger yield of the crop desired.

## 2ND EXPERIMENT.

### *Manuring of Ridged Land.*

The next question is as to whether, when the land is ridged, manuring will be effective, and if so, how should manure be applied to achieve the best result. Planting the crop on ridges exactly in the manner described above, ten tons of cattle manure per acre were applied in three different fashions as follows:—

(a) 10 tons of cattle manure were applied *in the furrows* before sowing the crop.

(b)  $7\frac{1}{2}$  tons of cattle manure were applied in the furrows before planting the crop, and  $2\frac{1}{2}$  tons on the ridges before sowing the crop.

(c)  $7\frac{1}{2}$  tons of cattle manure were applied in the furrows before planting the crop, and  $2\frac{1}{2}$  tons on the ridges at the time of sowing the crop.

Let us compare the yield of the plots so treated in comparison with a plot without manure. The figures are given below:—

*Cotton (Broach Desh, Strain 1027 A. L. F.).*

Treatment per acre.	Seed cotton yield per acre.		Average seed cotton yield per acre.	Increased yield in 1922-23 due to manure.
	1922-23.	1923-24.		
	lb.	lb.	lb.	Per cent.
(1) Ridged without manure.	660	575	617	...
(2) Ridged, 10 tons cattle manure in furrows.	757	668	712	15
(3) Ridged, 7½ tons cattle manure in furrows, 2½ tons on ridges before planting.	694	572	633	5
(4) Ridged, 7½ tons cattle manure in furrows, 2½ tons on ridges at planting.	705	574	639	7

*Jowar (Perio).*

Treatment per acre.	Yield per acre.				Average yield per acre.		Increased yield in 1922-23 due to manure.	
	1922-23.		1923-24.		Grain.	Fodder.	Grain.	Fodder.
	Grain.	Fodder.	Grain.	Fodder.				
	lb.	lb.	lb.	lb.	lb.	lb.		
(1) Ridged, without manure.	1,055	2,167	983	1,422	1,019	1,794	...	...
(2) Ridged, 10 tons cattle manure in furrows.	1,017	2,498	1,177	1,902	1,097	2,200	-4	+15
(3) Ridged, 7½ tons cattle manure in furrows, 2½ tons on ridges before planting.	963	2,475	1,097	1,982	1,030	2,227	-9	+14
(4) Ridged, 7½ tons cattle manure in furrows, 2½ tons on ridges at planting.	1,033	2,401	1,087	1,823	1,060	2,112	-2	+11

These results are clear and are of great interest and importance. They show that in the case of a deep rooting crop like cotton, using a slow acting manure like cattle manure, the best effect can be obtained by burying the manure in the furrows, so that as soon as the water conditions of the soil allow, the roots can be attracted to the manure, thus at the same time increasing the root range of the plants, and giving them ample food to consume. The effect was striking during the growth of the plants, for while this cotton plot appeared poor until the end of October, it ran ahead very rapidly after this date. The manure applied by the other methods is much less effective, and has disappeared in the second year. Taking, with the cotton crop, the combined effect of ridging and of the application of ten tons of cattle manure in the furrows, we have an increased yield of seed cotton as follows:—

- (1) Manure applied for cotton crop itself—42 per cent.
- (2) Manure applied for previous crop of *jowar*—42 per cent.

Of this by far the greater part is due to the ridging, and a less proportion is due to the manure. The first figure is for a wet year, the second for a dry year.

In the case of the other crop of the rotation, the *jowar*, the immediate effect of the manure, applied in any way, is *not* an increase in yield of grain but rather the reverse, but there is a considerable increase in the amount of straw. Again, the putting of the whole dose of manure in the furrows has given the highest yield of straw, though the application of a portion of the manure *before sowing*, on the top of the ridges has almost equalled it. The effect in the second year is marked both with the grain and straw, but more marked on the *straw*. This is interesting because the usual method of manuring in Lower Gujarat is to apply manure to the cotton, so that the *jowar* gets any residual benefit in the second year. Taking the combined effect of ridging and of the application of ten tons of cattle manure in the furrows, we have an increased yield of *jowar* grain and fodder as follows:—

- (1) Manure applied for the *jowar* crop itself—  
Grain, 16 per cent.  
Fodder, 53 per cent.
- (2) Manure applied for previous crop of cotton —  
Grain, 51 per cent.  
Fodder, 17 per cent.



PLATE 4.—Jowar 3' x 1' flat yield of grain 952 lb. per acre.

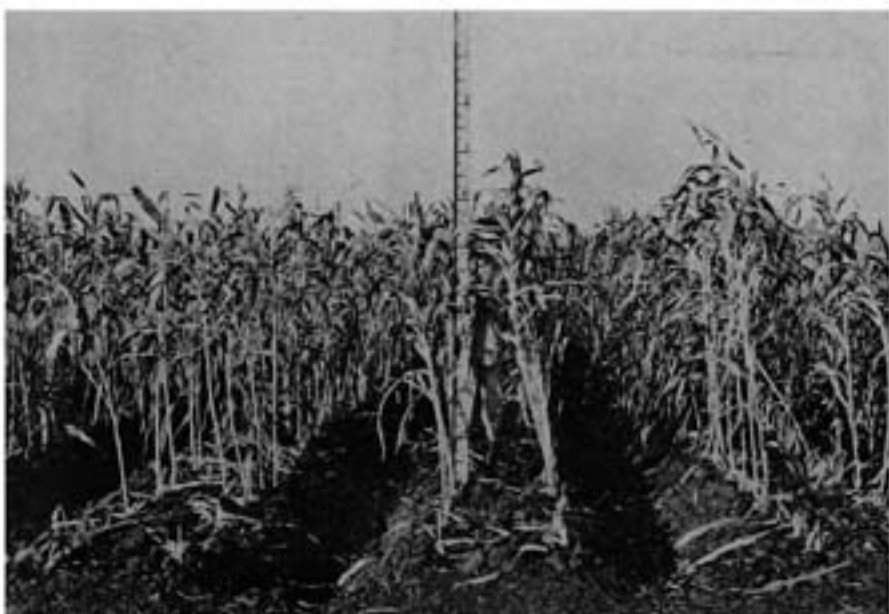


PLATE 5.—Jowar 6' x 2' x 1½' Ridged yield of grain 1,576 lb. per acre.



As in the case of cotton, by far the greater part of the increase in yield is due to the ridging, and a much smaller proportion to the manure.

The figures so far given are from the crops of 1922-23 and 1923-24. The records for these plots were, however, continued for 1924-25, which, as stated before, was an exceptionally good season. The results obtained were as follows :—

*Effect of Manure on Ridged Plots applied in 1924-25 to the Cotton or Jowar Crop.*

*Cotton (Broach Deshi, Strain No. 1027 A. L. F.).*

Treatment per acre.	1924-25, Seed cotton per acre.	Increased yield due to manure.
	lb.	Per cent.
(1) Ridged, without manure ...	1,006	...
(2) Ridged, 10 tons cattle manure in furrows.	1,154	15
(3) Ridged, 7½ tons cattle manure in furrows, 2½ tons on ridges before planting.	1,069	6
(4) Ridged, 7½ tons cattle manure in furrows, 2½ tons on ridges at planting.	1,090	8

*Jowar (Perio).*

Treatment per acre.	1924-25, Yield per acre.		Increased yield due to manure.	
	Grain.	Fodder.	Grain.	Fodder.
	lb.	lb.	Per cent.	Per cent.
(1) Ridged, without manure.	1,097	2,210	...	...
(2) Ridged, 10 tons cattle manure in furrows.	1,351	3,590	23	62½
(3) Ridged, 7½ tons cattle manure in furrows, 2½ tons on ridges before planting.	1,309	3,382	11	53
(4) Ridged, 7½ tons cattle manure in furrows, 2½ tons on ridges at planting.	1,357	3,486	24	58

These figures amply confirm what has been said before as to the effect of the manure on the ridged plots, and as to the manner of applying it and seem to make clear that in using the ridging system we have discovered how to make cattle manure effective. The yields obtained even for a good year, are very high for this part of Gujarat, and in the case of *jowar* show that in a favourable season, the effect may be very considerable even with this crop.

The combined effect in 1924-25 of ridging, and of the application of manure in furrows to the crops themselves is as follows:—

- (1) Cotton—44 per cent. increase of seed cotton.
- (2) Jowar—(a) 65 per cent. increase of *grain*.  
(b) 70 per cent. increase of *fodder*.

The *nett* result of the experiments just detailed is to show how it is possible to increase the yield of the two main staple crops on the black soil of Lower Gujarat by over 40 per cent. in the case of seed cotton (*kapas*) and by a substantial amount in the case of *jowar*, more especially in the latter case in the straw and fodder.

But we are not satisfied with the yields obtained in these cases, and it would seem more than probable that when the check to the plants due to partial water-logging is removed by ridge planting, a more careful study of the manuring adopted will lead to a still larger increase in the yield. To test this point a series of plots were laid out in 1923-24 in which, while retaining or omitting the manuring with cattle manure in the furrows between the ridges a rapidly acting top dressing of castor cake was given to the young plants on the top of the ridges. The ridges and the spacing of the plants was as before. Four plots (in duplicate) were used as follows, the quantities of manure being per acre:—

- (1) Flat, with no manure.
- (2) Ridged, with ten tons cattle manure in the furrows.
- (3) Ridged, with 448 pounds castor cake per acre as top dressing.
- (4) Ridged, with ten tons cattle manure in the furrows and with 448 pounds castor cake as top dressing.

The actual results in point of yield are given in the attached table.

*Cotton (Broach Deshi, Strain 1027 A. L. F.)<sup>a</sup>  
1923-24.*

Treatment.	Yield of seed cotton per acre.			Increased yield from manure.
	A.	B.	Average.	
	lb.	lb.	lb.	<sup>per</sup> Per cent.
(1) Flat, with no manure ...	519	474	496	...
(2) Ridged, with cattle manure.	632	610	621	25
(3) Ridged, with castor cake (top dressing).	530	494	512	3
(4) Ridged, with cattle manure and castor cake (top dressing).	600	657	628	27

*Jowar (Perio).*

Treatment.	Yield of Jowar per acre.						Increased yield from manure.	
	A.		B.		Average.		Grain.	Fodder.
	Grain.	Fodder.	Grain.	Fodder.	Grain.	Fodder.		
	lb.	lb.	lb.	lb.	lb.	lb.	Per cent.	Per cent.
(1) Flat, but no manure.	792	1,267	795	1,342	793	1,304	...	...
(2) Ridged, with cattle manure.	1,062	1,505	1,070	1,710	1,066	1,607	34	23
(3) Ridged, with castor cake (top dressing).	912	1,492	875	1,545	893	1,518	13	16
(4) Ridged, with cattle manure and castor cake (top dressing).	1,205	1,982	1,227	1,975	1,216	1,978	53	52

In the case of cotton, we have progressed no further by the use of the top dressing of castor cake during the early

growth of the plant. It looks as if the plant could take care of itself well enough if protected from water-logging, until it is able to send its roots far a-field for food in its later growth. In fact the castor cake alone has had practically no effect. When used in conjunction with cattle manure, it has given no serious additional advantage.

In the case of *jowar*, the result is otherwise. As would be expected with a more shallow rooted plant, the advantage gained in the early growth as a result of the top dressing is not lost, and the combined effect of the two manures used is fully obtained when they are used in conjunction. 1923-24, when this experiment was carried out, *was a dry year*.

It may be interesting to show how the effect on yield was produced which has just been described. In the case of cotton an attempt was made to ascertain whether the increase in yield was due to a larger number of flower buds being formed, or to a larger proportion of buds forming matured bolls. For this purpose the number of buds and bolls was counted on 20 plants (taken at random) in each plot, with results as follows:—

Treatment.	Number of buds per plant.			Number of bolls per plant.			Proportion, bolls to buds.
	A.	B.	Average	A.	B.	Average	Per cent.
(1) Flat, with no manure.	199	161	180	37	29	33	18.3
(2) Ridged, with cattle manure.	231	239	235	47	45	46	19.6
(3) Ridged, with castor cake (top dressing).	233	220	226	40	38	39	17.3
(4) Ridged, with cattle manure and castor cake (top dressing).	231	232	231	40	42	41	17.7

It is clear that the advantage achieved by the treatment is due to the formation of a larger number of flower buds in each case. There is a tendency, when a stimulating top dressing is used in the early growth of the plants, for a smaller number of the buds ultimately to ripen into bolls.

In the case of *jowar* it is interesting to note the effect of the treatment on the height of the plants, and on the number of nodes contained in them. The following figures show this, based in each case on the examination of 100 plants:—

Treatment.	Height per plant.			Average number of nodes per plant.		
	A.	B.	Average.	A.	B.	Average.
	Inches	Inches	Inches			
(1) Flat with no manure.	40	41	40.5	13	13	13
(2) Ridged, with cattle manure.	44	44	44	14	14	14
(3) Ridged, with castor cake (top dressing).	41	44	42.5	14	14	14
(4) Ridged, with cattle manure and castor cake (top dressing).	47	46	46.5	15	15	15

Even in this case with a relatively shallow rooted crop the figures show that the stimulation in the early stages with castor cake was less effective than the cattle manure at a later stage of growth, so far as production of height is concerned. The combined treatment, however, led to an effect which was practically equal to that given by the two manures added together.

This result was followed up in the same plot in rotation in 1924-25. No further cattle manure was added, but the top dressing of castor cake was repeated for each of the two crops. The yield figures only are repeated in these cases, but they were as follows:—

*Cotton (Broach Deshi, Strain 1027 A. L. F.).*  
1924-25.

Treatment.	Yield of seed cotton per acre.			Increased yield from manure.
	A.	B.	Average.	
	lb.	lb.	lb.	Per cent.
(1) Flat, with no manure ...	692	717	705	...
(2) Ridged, with cattle manure.	902	945	924	31
(3) Ridged, with castor cake (top dressing).	737	797	767	9
(4) Ridged, with cattle manure in 1923-24, and castor cake (top dressing).	1,065	1,127	1,096	55½

*Jowar (Perio).*

1924-25.

Treatment.	Yield of Jowar per acre.						Increased yield from manure.	
	A.		B.		Average.		Grain.	Fodder.
	Grain.	Fodder.	Grain.	Fodder.	Grain.	Fodder.		
	lb.	lb.	lb.	lb.	lb.	lb.	Per cent.	Per cent.
(1) Flat, with no manure.	812	1,825	775	2,125	794	1,975	...	...
(2) Ridged, with cattle manure in 1923-24.	1,190	2,655	1,172	3,300	1,181	2,977	48	51
(3) Ridged, with castor cake (top dressing).	1,040	3,340	1,025	3,340	1,032	3,340	28	69
(4) Ridged, with cattle manure in 1923-24, castor cake (top dressing).	1,287	3,865	1,282	4,065	1,285	3,965	62	103

In the exceptionally good year, the results obtained by ridging and manuring in the manners described were greater than in the less favourable year preceding. But the direction of the results is on the whole the same, though no fresh cattle manure had been added. The quick acting top dressing of castor cake gave a bigger effect, both with *jowar* and with cotton, and in the latter case its continuation with the dose of cattle manure in the previous year, gave a much greater advantage than would have been expected. This matter obviously needs close study, and suggests a method of profitably utilising such concentrated fertilisers. But the general results are confirmed that the ridging system allows the effective use of manure in a way which was not possible before.

**Summary of Results of Ridge Cultivation.**

The general result of the tests on cultivation on ridges, and of the effect of manuring under such ridge cultivation in the black soil of Lower Gujarat, is that we may consider the advantage of ridge cultivation as proved, and as giving a

substantial advantage to the farmer adopting the method. The actual advantages may be summarised as follows:—

(1) Ridge cultivation affords the best device we know of, for draining the surface water from the actual plants under cultivation in June, July and August each year.

(2) Ridge cultivation prevents the land being partially water-logged in the upper eight or ten inches of the soil during the period of heavy rain (Plates 2, 3).

(3) The number of gaps in the rows of plants in the ridge system of cultivation is very much less than in the flat.

(4) The amount of weeding in the ridged plots has been considerably less than on the flat, but the experiments so far have been made on fairly clean fields.\*

(5) The root development of both cotton and *jowar* is deeper on the ridged plots (Plate 6).

(6) The crop on the ridged plots get no check, and hence shows a more uniform rate of growth (Plates 1 to 5).

(7) The effect of ridging has not only been marked in a wet season, it is also felt in dry season, and hence is likely to be of advantage in any year in Lower Gujarat. This is probably due to the greater depth of root development which it allows.

(8) Under the ridge system of cultivation later inter-tillage is possible, even up to December, and deep inter-tillage has proved itself a distinct advantage to both cotton and *jowar* when done in the furrows.

(9) In the early stages of growth, the crop on ridges remains green while that on the flat becomes yellow during heavy rain. It is possible to work the soil on the ridges after heavy rains much earlier than on the flat.

The question of the best method of manuring under ridged conditions and of the best kind and quantity of manure to apply must be left unsettled for the moment. But it is clear that for cotton, the best method of applying cattle manuring is to bury it deep in the furrows. When this is done the crop makes a remarkable, rapid and luxuriant growth after the end of the normal monsoon.

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\* Experiments in 1924 in a less clean area showed that the amount of weeding is really less.

### Method of Ridging Land.

The question now arises as to the best method to be adopted to make and maintain the ridges required in the method of ridge cultivation discussed. So far we have dealt with ridges made 14 inches high, with a distance of five feet between the ridges. These have been made by a combination of ploughing\* and hand labour in the hot weather. The cost of doing this with the very heavy soils of Lower Gujarat which become almost unworkable when exposed to the sun in the dry weather, has been large, amounting to Rs. 62-8-0 per acre when made in May 1922. Although when made, we have proved that the ridges will last for three years at least, yet the cost is very high and is practically prohibitive. A method must, therefore, be devised by which suitable ridges can be made more cheaply, or good results must be shown to be obtained by smaller ridges.

The fact that considerable effect could be obtained by using lower ridges has been made clear by a test made in 1923, on cotton, using ridges three feet apart and nine inches high. These were opened by ridging ploughs at the time of inter-ploughing the previous *jowar* crop. No manure was applied in either case.

Treatment.	Yield seed cotton per acre.	Increase over flat plot.
	lb.	Per cent.
(1) Flat plot ...	435	...
(2) Ridged plot as above.	512	17

When we consider that 1923 was a dry year and hence specially favourable for *flat* cultivation the increase is very good, and compares well with the 22 per cent. increase which was obtained with the ridges of the full original size. It suggests a method of making useful ridges at a minimum cost, for this only costs Rs. 2-4-0 per acre above the ordinary amount spent on cultivation.

Modified methods have now been applied on a large scale in the Surat District, 285 acres being under ridge cultivation in 1923, 602 acres in 1924, and over 1,300 acres in 1925.

\* Using the heavy "Gallows" plough of Messrs. Ransome Sims & Jeffries.



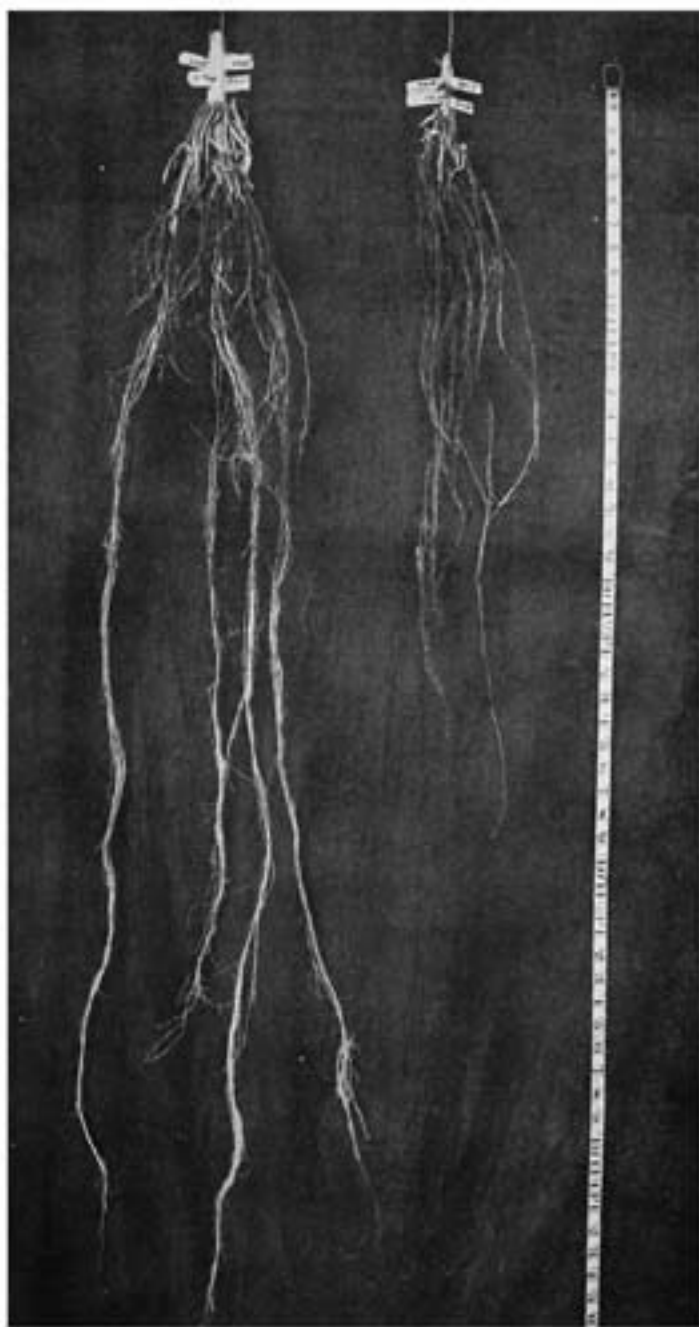


PLATE 6.—Root Systems of Jowar Plants on Ridge as well as on Flat.  
Ridged on left: Flat on Right.

Three systems have been adopted:—

(1) When there is a favourable break in the rain in June-July, ridges nine inches high and three feet apart can be prepared by the Chattanooga Middle Breaker, Nos. 19 and 20, costing Rs. 55-8-0 and Rs. 58, respectively, worked by a single pair of bullocks, or by the P. and O. 10-inch Middle Buster costing Rs. 70. Middle Breakers are usually well suited for the sandy or lighter types of soils but are workable even in black or *besar* soils when the land is in proper condition in the monsoon. The Middle Buster is heavier to work than the Middle Breaker and is usually well suited for heavy black soils. It usually requires a pair of good sized cattle to make ridges ten inches high and three to four feet apart, by a special attachment of tail-sheets, while the Middle Breaker with a similar attachment, prepares ridges up to nine inches high, and three to four feet apart, and can be worked by a light type of animal.

The Middle Breakers are made with steel shares and cast iron mould boards, while the Middle Busters have both the share and mould boards of steel, so in the long run the initial expenditure done on purchasing a Middle Buster pays its way to the cultivator. As compared with the country implements such as blade harrows (which have usually a packing action, forming a hard pan deleterious to the progress of the young crop), both the types of implements described are specially provided with back rudders and cutters which prevent packing and pan formation (*vide* Plates 7A and 7B).

This is the simplest system, and the actual making of the ridges does not cost more than Rs. 1-4-0 per acre. The average outturn of work of one set of implements and one pair of bullocks comes to three acres per day.

(2) The method already described is also applicable with certainty when the land is left fallow during the rains for a *rabi* crop of wheat or *jowar*. Subsequently ridges are prepared with the above implements for the next cotton crop before the monsoon.

(3) If a crop of *jowar* be drilled on the flat in rows three feet apart and the land between the rows is ploughed in September or October by the P. and O. 10-inch Middle Buster (instead of by the country ploughs

according to the local method) ridges can be made three feet apart and nine inches high which, with slight repairs in the following cold weather, will work very well. This method can be followed by a cultivator who has only one pair of bullocks. It would cost Rs. 2-8-0 extra per acre, with average work of  $1\frac{1}{2}$  acres per day or more according to the condition of the soil.

This method not only prepares the land for the next crop, but is beneficial to that in which it is done. When ridges, nine inches high and three feet apart, are prepared by inter-ploughing with the Middle Buster between rows of *jowar* grown on the flat three feet apart in September-October, the standing rows of *jowar* are earthed up to give due support and prevent lodging, and to keep the crop well mulched so as to effect proper formation and development of grain. This is especially advantageous in dry seasons to the standing *jowar* crop to enable it to resist drought conditions, as was very markedly shown in 1923-24. The following are the results of final inter-tillage in the *jowar* crop by this method as compared with shallow inter-tillage, though the yield of fodder was reduced:—

*Method of Inter-tillage.*

	1922-23.		1923-24.	
	Grain.	Fodder.	Grain.	Fodder.
	lb.	lb.	lb.	lb.
Ridged, with shallow inter-tillage.	933	1,846	896	1,547
Ridged, with inter-tillage by the method described.	1,055	2,167	983	1,422

Even in a wet year (1922-23) while there was a considerable increase in yield of fodder, there was also an appreciable increase in yield of grain due to final deep inter-ploughing. Thus in both dry and wet seasons the method described of forming ridges by deep inter-tillage between the *jowar* rows has given considerable advantage. This is more than sufficient to pay the extra cost of this operation, while it also prepares the frame work of the ridges for the next cotton crop.

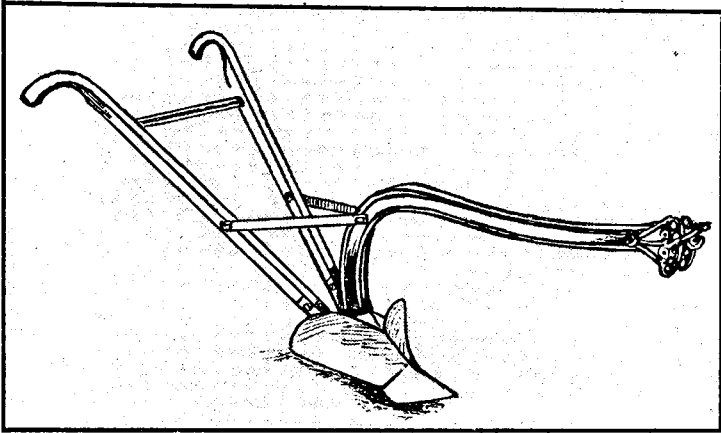


PLATE 7A.—Chattanooga Middle Breaker No. 19.

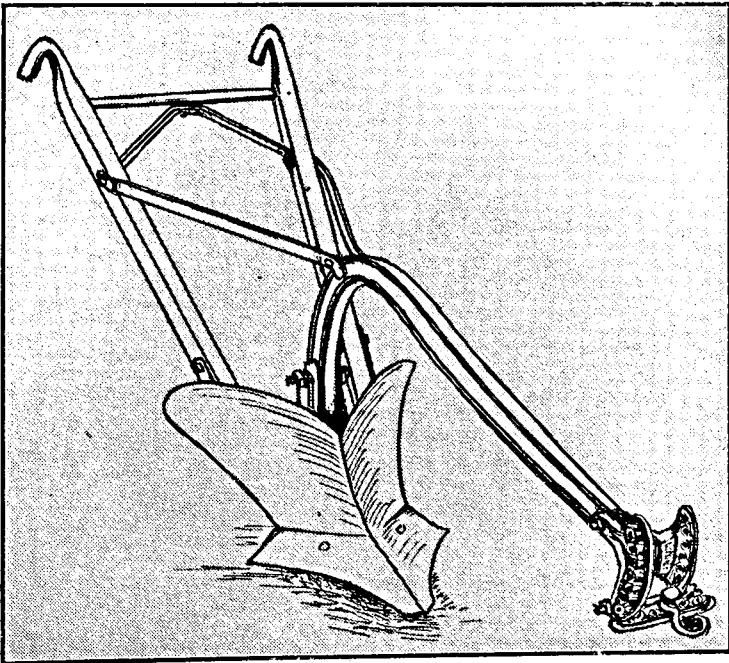


PLATE 7B.—P. & O 10" Middle Buster.

Now the question arises, if this method be employed, how to remove the *jowar* stubbles from the tops of the ridges. This can be achieved by two methods:—

(1) by hand digging at a cost of Re. 1 per acre where manual labour is available,

(2) by the ordinary harrow of the Broach or Surat District in two operations in April and May at a cost of Rs. 1-8-0 per acre.

This disturbs the tops of the ridges somewhat seriously, but the mulch and the ridge framework are not entirely lost. The damage done can be repaired easily by the Middle Busters with tail-sheets, at a further cost of Rs. 1-8-0 per acre, working them twice in the same furrows. These ridges will be ready before the monsoon, ready for dibbling cotton three feet by three feet apart on their tops.

Then the question remains about the successive weedings and inter-culturings between the ridges with cotton crop grown in the manner described. The ordinary blade harrow is not found very efficacious for these operations. The most successful implement for this sort of inter-cultivation between the ridges has been found, from the experience of the last three years on a very large scale in the McCormick Cultivator No. 55 costing Rs. 45 (*vide* Plate 8A).

After the final rain in October the tops of the ridges are broken up by ordinary Broach harrow working cross-wise and Middle Busters are passed to reform the ridges. Then in the final furrows ordinary country ploughs are worked to keep a mulch in the furrows. This operation can also be done by passing the Middle Breakers or Busters after removing their mould boards. This will keep a sufficiently deep mulch near the plants on the top of newly formed ridges. This is very important in preventing the serious cracking of soils which will otherwise result in damaging the crop. By doing such an effective Middle Breaking or inter-ridging, the roots of the cotton plants are driven down to the lower moist substratum at an opportune time when the roots begin to go in search of moist substrata. This has the advantage of resisting drought in a dry year, while in a wet year the proper aeration, necessary for good bearing of bolls, is secured.

The cotton stalks are dug out by manual labour and just at the start of the monsoon, *jowar* can be skilfully drilled on the ridges after slight repairs of the same by Middle Busters or by small three-foot Reversible Disc Harrows. Thus the cotton-*jowar* rotation can be maintained successfully, keeping the land free from weeds and in good physical condition.

So far we have dealt with the practical methods for making ridges of the size and character which we think will usually be adopted. But to get the *maximum* benefit from the ridge system larger ridges five to six feet apart, and 14 inches high should be prepared.

The safest way to prepare such ridges is to do it immediately after the *jowar* harvest in January and February when the land can be ploughed seven to nine inches deep, by means of tractor ploughing. Then the clods should be crushed and ridges prepared by one of the big ridging ploughs such as that by Messrs. Ransome Sims & Jefferies (Plate 8B). When ridges are so made, they will be ready for the next monsoon and will remain permanent for at least four to six years with slight repairs. So made, the cost will be from Rs. 20 to Rs. 25 per acre.

Cotton is then dibbled on ridges 14 inches high and five to six feet apart, in single rows, the plants being placed two to three feet apart according to richness of soil, the richer soil having the wider distance, giving full scope for the development of the plants. The weeding and inter-culturing on such permanent ridges are best done by the Reversible Disc Harrows (*see* Plate 9) by the special in-throw arrangement straddling the ridges and the row crop, hilling up and burying the weeds by the tilting action of the discs, by adjusting the serrated connections on the pivotal casting. This implement has solved our long felt want of a suitable inter-culturing implement on ridges for the cotton crop and we have used it for the last two years. It can be worked by one pair of good sized bullocks. This has both the advantages of reducing the weeding to a minimum, and dealing with 50 per cent. more area than the ordinary blade harrows. Besides these, it has got two other advantages, (1) it prevents pan formation and (2) keeps the tops of the ridges deeply mulched which hinders cracking of the soil and tearing the roots asunder.

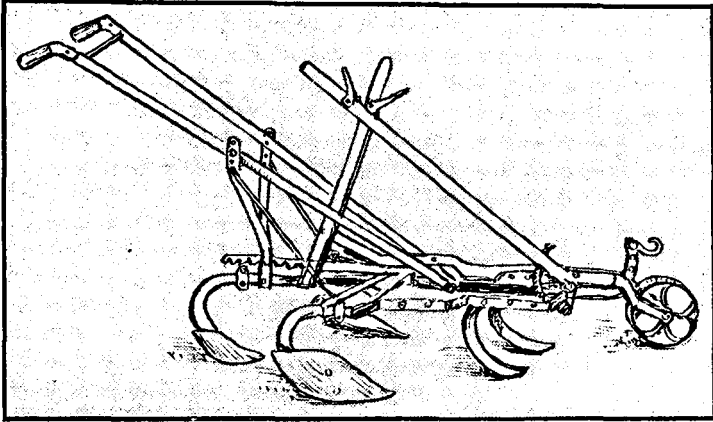


PLATE 8A.—McCormick Cultivator No. 55.

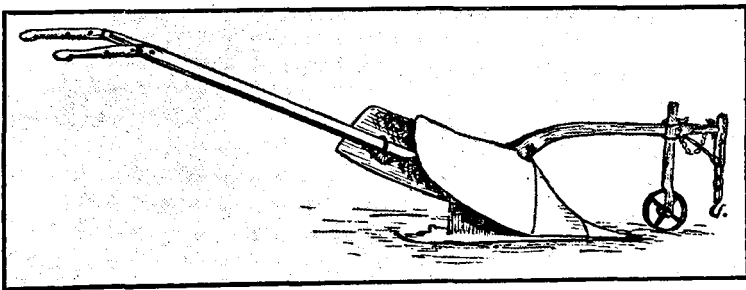


PLATE 8B.—Ridging plough.

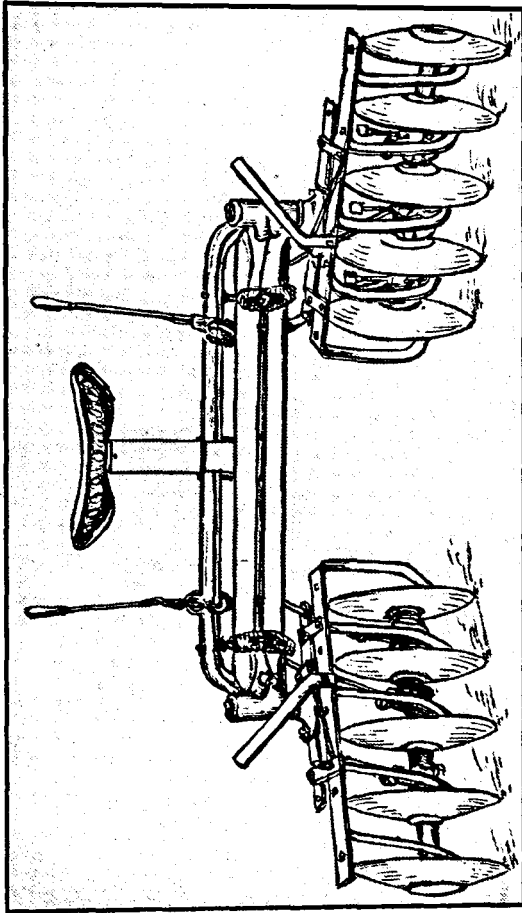


PLATE 9.—Reversible Disc Harrow.



Such a condition is most desirable for successful development of bolls in the later stages of the cotton crop on this type of black soil.

During the year 1924-25, 30 acres of ridges, six feet apart and 14 inches high on the Surat Farm, and 93 acres of ridges, five feet apart and fourteen inches high in the District, have been worked by the Reversible Disc Harrow in June after the rains by four repeated operations in the first break of monsoon at a cost of Rs. 7-8-0 per acre. But this can only be done when there is a break in the rains in June-July before sowing. The same implement has been successfully worked for inter-culturing the same cotton crop.

After the cotton crop is dug out, the ridges can be repaired by the above mentioned disc harrow in preparation for drilling the two rows of *jowar*, two and a half to three feet apart, on ridges five to six feet apart, respectively. This will keep the *jowar* lines above the furrows on both sides of the ridges. Inter-culturing in the early stage of the crop may be done by the McCormick Cultivator in the furrows as well as on the ridges. At the time of final inter-culturing in September-October, the inter-culture is done by the Middle Buster both in the furrows and on the tops of ridges by bullock power; this would earth up each *jowar* row from both the sides and thus the *jowar* plants get the chance of securing the deeper penetration of roots which is necessary for good grain formation, as dealt with previously.

Ridges thus split up by the above operation, can be made up into one by the Reversible Disc Harrow, removing the stubbles of *jowar* and burying them in the furrows, automatically. This affords a good chance of putting manure in the furrows, and so burying it deep when the ridges are thus remodelled. This is a very easy operation in even April and May, owing to the existing deep soft mulch worked up by the Middle Busters as described above. In this way every two years the position of the ridges can be maintained or changed easily if preferred by the cultivator at a nominal cost of Rs. 5 per acre.

Thus the repairing charges of ridges are merely nominal, if suitable opportunities are utilised by well suited implements.

### Conclusions.

The methods described in the present bulletin represent a very serious advance in methods of cultivation, which would seem to have a very wide application in the black soil tracts in Lower Gujarat and possibly over a much wider area. They show a method whereby, by growing crops on ridges and not on the flat, with judicious cultivation between the ridges, the yield of cotton (seed cotton) can be raised, whether in wet, dry or normal years by an average of 23 to 25 per cent., and that of *jowar* by an average of over 23 per cent. of grain and from 5 to 10 per cent. fodder. Further this method of growing crops forms a basis for the profitable use of manures and fertilisers, to dry crops, which has not hitherto been a paying proposition in these areas. This method has already come into use over 1,300 acres and is now extending as rapidly as assistance can be given to apply it.

Further the methods now worked out for applying this ridge system of cultivation in the Surat District and described in the present bulletin are cheap and can be worked with the ordinary bullock power available. True, they involve the use of some new implements not hitherto employed in the district in question. But these are available, and as they are within the means of the cultivators and can be stocked by the local association for agricultural improvements which now exist, there is reason to anticipate a large extension of the method described in the near future, and hence a considerable increase in the production and hence in the returns from the land.

## APPENDIX.

It is a matter of considerable interest to know whether the additional aeration allowed in the soil by the ridge system described in the present bulletin leads to the presence of a larger amount of nitrification in the soil, and hence of a greater quantity of available nitrogen in the form of nitrates. We owe to the kindness of Mr. D. L. Sahasrabudhe, Agricultural Chemist to the Government of Bombay, the figures reported below of analysis of the soils made during the year 1923-24. Samples of soil and subsoil were collected throughout the season from August onward, both on ridges which were cropped and uncropped and on flat land adjacent. They were dried immediately and rapidly at a temperature of 50° to 60° C. The results of determinations of the nitrates and nitrites in dry soil are attached.

### EFFECT OF RIDGING ON CONTENT OF NITRATES AND NITRITES IN SURFACE SOIL AND SUBSOIL UNDER COTTON AND JOWAR.

#### *Nitrogen as Nitrates and Nitrites in Soil under Cotton.*

	• Surface soil.		Subsoil.	
	Ridge.	Flat.	Ridge.	Flat.
		Parts per	100,000.	
1923—				
August 25	.209	.212	.147	.151
October 15	.269	.220	.210	.116
October 25	.315	.252	.212	.156
November 26	.288	.270	.162	.119
December 21	.273	.151	.119	.120
1924—				
January 24	.142	.199	.134	.176
February 27	.218	.215	.143	.129
April 1	.247	.173	.163	.153
April 29	.193	.149	.155	.160
May 28	.208	.154	.125	.123
July 1	.162	.143	.130	.134
August 6	.159	.153	.146	.152

Both in the surface soil and subsoil the nitrates and nitrites are distinctly higher on the ridges than on the adjoining flat land. At the end of October the difference becomes very great.

*Nitrogen as Nitrates and Nitrites in Soil under Jowar.*

	Surface Soil.		Subsoil.	
	Ridge.	Flat.	Ridge.	Flat.
1923—		Parts per	100,000	
August 23	·160	·265	·153	·150
October 15	·302	·206	·212	·154
October 25	·199	·179	·160	·098
November 26	·166	·157	·166	·120
December 21	·244	·211	·151	·165
1924—				
January 24	·152	·150	·135	·119
February 27	·182	·217	·177	160
April 1	·204	·880	·127	·221
April 29	·183	·155	·136	·193
May 28	·150	·086	·129	·063
July 1	·226	·158	...	·135
August 6	·153	·134	·219	·135

The results in general tell the same story as with cotton, though there are certain samples, such as those on February 27, April 1, which need explanation.

## THE BHAGNARI BREED OF CATTLE IN SIND AND BALUCHISTAN.

There is a well known breed of cattle, large and exceedingly strong, found in Upper Sind and much sought after by dealers from the Punjab, under the name *Bhagnari*. They have extended their range as a result of their suitability for agricultural, siege-train, and army transport purposes. Detailed information as to the character of this breed in its home in Baluchistan seems to be lacking, and the present account is the result of an investigation by the Government of Bombay Agricultural Department to see and study it in its place of origin. The question really before us was, in fact, how far it is possible or advisable to attempt regular breeding of this fine type of animal in Sind, and how far, if this could be done, it would be suitable for general agricultural purposes in that province.

### THE HOME OF THE BREED.

The *Bhagnari* breed of cattle finds its home in the Kachhi district of the territory of Baluchistan. This district consists of a flat triangular plain with its base on the Upper Sind Frontier Districts of Sind, and is enclosed by the Marri and Bugti Hills to the east, and by the Kirthar and other mountain ranges to the west. To the north-east of its apex lies the British tract known as Sibi. The *Bhagnari illaqua* or area starts south from the village Mithri, which is twelve miles south of Sibi station and stretches along the tortuous course of the Nari river towards Kanda and Tamboo. It terminates a few miles from the border of the Upper Sind Frontier District of Sind. The line of the North Western Railway proceeding towards Quetta forms its eastern boundary, from which it stretches west to the Jhalawan hills. The town of Bhag, formerly the winter home of the Khan of Kalat and now the head quarters of the *tahsil* of that name, is situated on the Nari river and is the centre of the tract. It divides the area into two parts, the Upper or Bala Nari and the lower or Zerin Nari, and stands about 5,000 feet above sea level.

The physical characters of this area, forming the centre of the breeding of *Bhagnari* cattle are striking. It forms an

alluvial plain of recent origin, and the present alluvium has been deposited chiefly by hill torrents, and thus the soil throughout is a light loam known as Math, moderately mixed with sand, light, medium, and heavy stiff clay (*Khauri*) which cracks heavily on drying. The organic contents of the soil are low, as is usual in that of such an arid country. All the hill torrents run into the Nari river, and this river is dammed by a series of large earthen embankments constructed in the bed of the rivers by the co-operation of the cultivators. The most important of these dams is at Gadi twelve miles north of Bhag. It is by means of these dams that the whole tract is irrigated by heavy flood irrigation, by means of canals taken from the river. Hence the upper or Bala Nari area has the first call on the water which may be in the river.

The rainfall of the Kachhi district varies from two to five inches. The temperature in the hot weather runs up to 120° F. and sinks in winter to below 40° F. Sometimes frost occurs. In the hot weather, the country is subject to the hot wind storms known as *luk* or *jhola*, and even drinking water is scarce from March to the middle of June. Hence the climate will be seen to be very hot, dry, and scorching in the hot weather, and very cold and almost equally dry in the winter.

Except along the foot of the western hills, that is to say, over an area of a few thousand acres, the whole aspect of the country is desolate and bare. The trees and shrubs are scanty and thorny. The chief large shrubs and trees are the *kandi* (*Prosopis spicigera*), *kirar* (*Capparis aphylla*), *khabhar* (*Salvadora oleoides*) and few *ber* (*Zizyphus jujuba*) trees specially in irrigated tracts, and *lai* (*Tamarix*) in river beds. *Ak* (*Calatropis gigantea*) is very common. After the first flood or rains in June, many good grasses are found, and form excellent pasture. The most common ones are *gamh* (*Panicum antidotale*) which is excellent fodder, and grows to a height of four to five feet. This grass tillers profusely, and even forms a grain useful in times of famine for the starving people. Other common grasses are *khiv* (*sporobolus Indicus*), *chhabbar* or *hariali* (*Cynodon Dactylon*), *ghander* (*Andropogon Foveolatus*), *drab* (*Eragrostis Cynosurides*), *kabah* (*Cyprus rotundus*) and others. *Gamh*, *khiv* and *ghander* are considered to be the best and most nutritious grasses, and they grow abundantly on the plains.

The cultivated area in Kachhi, in a normal year, varies from 60,000 to 80,000 acres, and is limited to 95 to 100 villages with a population varying from ten to over two thousand. The chief staple crop is *jowar* (*Andropogon sorghum*) with an admixture of *mug* (*Phaseolus mungo*) and *til* or sesamum (*Sesamum indicum*). The *jowar* crop will give two ratoon crops if it gets a shower or flood in October and in February. This is peculiar to Kachhi. *Jowar* stalks remain in a green condition even when the crop is ready for harvest. If there are showers in September two varieties of oilseeds are grown, *sireh* (*Brassica campestris*) and *jamba* (*Eruca sativa*). *Bajri* (*Pennisetum typhoideum*) is rare except in sandy places. Special fodder crops are not grown except when early showers come in May, when *kiring* (*Setaria italica*) is grown. This gives a first cutting in June, and a second and third in July. It is succulent and very nutritious.

#### THE HISTORY OF THE BREED.

Very little is known about the Bhagnari breed till the beginning of the fifteenth century when the Baluchie people are said to have taken possession of the tract. Since that time this breed has been a prime favourite with the people, the cattle are only second in importance to their horses. The present name Bhagnari is derived from that of the town Bhag, which forms the centre of the area, and Nari, that of the river which runs through the valley. It is the Bala Nari or Upper part of the Bhag *tahsil* which produces the cream of the stock at present. The chief centres are Mithri, the Jaghir Inam of Nawab Bahadur Raisanis Baluchies, the Haji, Dandore and Gadi areas twelve miles above Bhag town. Outside these areas and specially when going down the lower (Zerin) Nari valley towards the Sind boundary, there is a gradual admixture of cattle of other breeds or of *Bhagnari* animals of a lower grade. The Nasirabad *tahsil*, a buffer area between Sind and the Baluchistan territory has, almost entirely, a very mixed breed of cattle (*khar*) between the Sind and Bala Nari breeds.

The total number of animals in the area producing pure Bhagnari cattle is not exactly known, but an approximate estimate for a village of good size such as that of Haji, Gadi, Mithri, &c., with a human population of 1,500 to 2,000, would be 250 to 300 head of *Bhagnari* cattle. Fifty per cent. of these would be cows of breeding age, and the remainder

bullocks and bulls (30 per cent.) and young stock (20 per cent.). The total number of plough cattle would not exceed 5,000 to 7,000 in the Bala Nari, and 6,000 to 8,000 in the Zerin Nari.

In the Jacobabad District of Sind (Upper Sind Frontier) a few herds of good *Bhagnari* cattle, but not many, were seen. In the area of Khan Bahadur Bahadur Khan Khoso and in that of his son, Khan Bahadur Dilmurad Khan, there were good *Bhagnari* cattle. In the former estate forty head of true *Bhagnari* cattle were observed, out of which nineteen were breeding cows, and the rest young stock, two bulls and nine bullocks; in the latter estate there were seven cows, one bull, thirteen young stock and five bullocks. In Khan Saheb Sher Mohomad Khan Bijarani's area and three other places, there were also good specimens of cows, bulls, young stock and bullocks, but not many.

#### DESCRIPTION OF THE BREED.

A fair description of these cattle has been given by Pease and Baldrey in their book on Punjab Cattle,\* but it was apparently based on specimens which had been imported into the Punjab. There does not seem to be any other careful and detailed description of the *Bhagnari* cattle published hitherto, though several officers of the Veterinary Department in Sind have made notes upon them. The description, which follows, is based on the present investigations in Kachhi in 1923, but use of unpublished notes by Major Trydell (1909) and M. Abdullah (1917) referred to above has been made.

There are two distinct types of *Bhagnari* cattle:—

(1) The first of these is heavier than the other, and has a little fawn coloured hair on the upper frontal region of the head, specially over the frontal ridge. Generally, however, it has a white colour tending to iron grey. This type stands to a height of 56 to 58 inches at the shoulder with a girth of 80 to 90 inches. One exceptional animal seen was much more massive than this average, standing 63 inches in height at the shoulder with a girth of 95 inches.

(2) The second type is a little lighter, and never has any fawn coloured hair on the frontal region.

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\* H. T. Pease and Baldrey—Breeds of Indian Cattle, Punjab Notes on Indigenous Breeds of Cattle in the Punjab (1903).



There is, however, very little real difference between the two recognised types, and one general description will apply to both, with the exceptional points already noted.

#### BULLS AND BULLOCKS.

(a) *General Appearance*.—They are very handsome, well proportioned and symmetrical.

(b) *Temperament*.—The animals are very domesticated, the bullocks are very docile, not fiery or timid.

(c) *Weight*.—When full grown the bulls and bullocks weigh from 1,250 to 1,450 lbs.

(d) *Colour*.—They are invariably white, with iron grey or blackish colour at the shoulders, neck and hump with a slight fawn colour on the frontal ridge in the heavier section of the breed.

(e) *Skin and Coat*.—The skin is thin, pliable, waxy and with a black colour, with a coat of white silky hair, except on the shoulder and neck in bulls. Some are darker than others, but the white colour generally predominates.

(f) *Bones*.—These are fairly clean and firm.

(g) *Head*.—The frontal and parietal regions are broad, and massive. The frontals are specially broad, thus placing the set of the horn cores very far apart. The general look is very bovine, but well carried.

The horns are black, short, stumpy and thick, set widely apart, and directed in general outward and upward, ending in broad and blunt tips. The line midway between the horns is usually depressed very broad at the frontals which seem raised slightly. A prominent linear ridge runs as a groove from *nimburi* to muzzle; it starts arching from the lower part of the frontal dipping at a level with the superior commensure of the eyes, and recurves slightly forward just above the muzzle. The jaws are light. The muzzle is small and black, the nasal opening is round and slightly raised sloping slightly on both sides. The eyes are large, full, mild and slightly bright. The eyebrows are prominent, slightly raised at the upper process and covered with thick overhanging rough skin. The ears are medium sized, half carried, with orange colour inside with a black spot on the inner middle line.

(h) *Neck*.—This is straight, comparatively short and thick. The dewlap is well developed, but not massive and pendulous; it folds down when the neck is raised erect.

The dewlap is fairly fine, beginning a few inches behind the chin and ending at the sternum; it may in exceptional cases extend as far as the naval, and is well pouched at the armpit.

(i) *Hump*.—The hump is well developed, slightly inclined backward.

(j) *Body or Trunk*.—The body is large and long in proportion to the neck, and the legs deep and long, with large girth. The barrel is long and deep, with well sprung ribs, indicating capacity, and endurance for draught. The chest and sternum are broad, deep and strong.

The back is level, fairly straight, dipping very slightly immediately behind the hump, and rising again very slightly to the croup.

The loins are broad and powerful. The croup is large, wide at the hips, medium at the pin bones, higher up than withers and not as sloping as is found in Sindhi cattle.

(k) *Tail*.—The tail is fine, tapering to a well bunched tuft of black hair, fairly high set and carried, reaching much below the hocks or even the fetlocks.

(l) *Limbs*.—The limbs are strong and of medium length, well proportioned to the trunk.

As regards the forequarters, the shoulder is strong, muscular and broad, sloping slightly, somewhat light but with good draught qualities. The forelegs are fine and straight with clean, strong bones; the arms are muscular, coned down with muscles and powerful; the cannon is clean and strong; and the pastern is strong with a band of blackish hair in bulls. The forefeet are medium in size, with strong black horn, and well set for hard work.

As regards *the hindquarters*, the hip bones are prominent and set wide apart. The hind legs are more or less straight, well muscled, but not massive. The thigh is broad and well muscled for draught.

(m) *Sheath*.—The sheath is large, but not pendulous and more or less triangular, well furnished at prepuce. Breeders prefer for breeding purposes a sheath more or less buttoned up.

(n) *General*.—The bulls become active for service after the age of 2½ years at the earliest, and serve for eleven years. The bullocks are powerful, fairly quick, very enduring, and easily managed. They stand well changes of climate from

the scorching heat of the Sind plains to the piercing cold of the frontier winters. They feed easily and well. The price of a good bull is about Rs. 250, but the best specimens fetch from Rs. 550 to Rs. 750.

#### Cows.

The general characters are similar to those of the bulls and bullocks. The special points deserving of remark are as follows:—

(a) *General Appearance*.—They are very handsome, attractive and docile.

(b) *Temperament*.—The animals are very docile and would be fit for dairy purposes if developed in this end.

(c) *Weight*.—When full grown the cows weigh from 850 to 1,000 pounds.

(d) *Head*.—The face of the cows is fine, long and tapering much more so than with the bulls and bullocks.

The forehead is not so prominent as in male animals nor so wide. The facial groove is prominent.

The nasal bone is long, prominent and round with prominent clear facial veins.

The horns are of medium size, but some specimens have long finer horns, growing outward and upward, and slightly inclined inward at the top.

(e) *Udders*.—The udders are fairly capacious, but fleshy. The average milk yield during the lactation is 12 pounds per day.

(f) *General*.—The cows start breeding at the age of  $3\frac{1}{2}$  years, and usually throw calves regularly up to the fifteenth year, though they may continue up to the age of eighteen. They usually drop a calf every sixteenth month.

#### CALVES.

The calves are white in colour at birth, with a marked fawn colour on the head, hump, shoulder and upper part of the neck, which with advancing age disappears gradually. Calves range in weight at birth from 50 to 60 pounds.

Measurements taken on a number of typical animals in their own country in Kachhi are recorded in the appendix.

### BREEDING CONDITIONS IN THE HOME OF THE BREED.

As already explained, the tract where these cattle are bred is a rich alluvial plain, which has a sufficient supply of drinking water in the Nari River from July to February, but distinct scarcity from March to June. This difficulty of water supply is overcome by digging temporary wells in the lowest part of the river bed. Almost every cultivator family has its own well, and the amount of water which soaks into these wells is sufficient for his family and animals. Further in this tract there is very little natural growth of fodder on the open land throughout the year, so that the cattle cannot be bred or kept on the open ranching system. The insufficiency of shade is a vital factor in a country with such extremes of climate, which would make an open ranching system almost impossible, and in any case it is a distinct difficulty with breeding in this tract. The people partially avoid this difficulty by sending the animals out for grazing, in the hot weather, only in the early morning before 10 a.m. From that time they are kept under temporary shades (*chappers*) in their house compounds, fed and attended there. When the *jowar* crop is four feet high the animals are tethered along the bunds and the sides of the fields and the feed they get is supplemented by weeds, grass and *jowar* leaves brought from the fields. In any case, and in every season, the cattle must be back in the village before dusk, for safety.

In the rainy season, when rain occurs grasses grow luxuriantly throughout the country, and the whole tract forms a rich pasture, which in a favourable year remains green until the end of November. As already described the *jowar* grown here remains green even after harvesting, and forms a very good hay. By stocking this hay, and with a certain amount of grazing up to the end of March, the animals are kept going during the period of stress from April to June, with a small supplement of *jowar* grain, and occasionally of oil seed cake.

### BREEDING PRACTICE.

The original breeders of Bhagnari cattle were the Baluchi tribes, and a great deal of the breeding is still in their hands. They understand well the management of breeding cattle, and from this point of view the *Bhagnari* tract is divided into zones. Each zone consists of a central village

owned by a *jagirdar* or by *zemindars*, and stretches from this centre over an area of from five to ten square miles. Here the *jagir-lar* or *sardar* possesses land and cattle, and both he and his tenants keep bulls of known blood, especially on the side of the sire. The bull calves of known pedigree, which conform to the ideal type, are given full liberty to suck their mothers when at heel, are attended to carefully, and fed well, and are always housed well. When they attain the age of three years, that is to say, when they are about to cut the four middle incisor teeth, they are used for service and are mated with any good cow that may be brought for covering. In no case are the bulls allowed to roam about freely. No service fees are charged, for, the owner, by custom, is not allowed to refuse anyone the service of his bull. If the bull is found to be growing too heavy before cutting the sixth tooth, it is almost always removed from service, castrated, and used as a bullock. If this is not done they are allowed to serve up to the age of five years.

By adopting this practice, the breeders maintain a continuous success of new bulls, and every two years a new animal heads the herd. This system would seem at first sight to be uncertain, but it certainly results in cattle very true to one type. The breeders of different zones often introduce new blood from one another's stock, and so prevent close in-breeding. They always maintain a reserve stock of young bulls, giving them light work, and when not wanted they are castrated and sold as bullocks. The stock is very highly prized, and in no case and under no extreme of famine or poverty would the breeders part with their foundation breeding stock, especially the cows. The "Sale trade pass", that is to say, the necessity of Government or Sardar's permission to sell an animal is the main factor in maintaining the cream of the breeding stock.

#### FEEDING, MANAGEMENT AND CARE.

It has already been pointed out that the Nari tract produces three or more varieties of nutritious grasses in the *kharif* season in the plains. In addition extensive areas are sown with *jowar* with a sprinkling of pulses, especially *mug* (*Phaseolus mungo*). The *jowar* gives excellent hay, *kadbi*, and this when stored forms the mainstay of the feeding during the annual period of stress. The *mug* yields *kati*, or the remnant of leaves, stalks and dry pods which remain after the dry seeds have been removed,

and this with a sprinkling of crushed inferior *jowar* grain serves as a concentrated food to milch cows, calves and bulls. This latter is given to cows at the time of milking, and is fed to calves and bulls with their ordinary chaffed fodder. The animals are thus always kept in good condition.

When there is any grazing to get, the village cows are herded together for grazing at nine to ten o'clock in the morning after the morning milking, and are brought back at dusk to the village. When the *jowar* grain crop is in the milk stage, and the general *farman* or declaration has been given to each landowner by the Khan of Kalat fixing his share of the produce, then each breeder takes his cattle on to his farm, tethers them on the field embankments (bunds) near shady trees if possible, and feeds them with grass, *jowar* leaves, weeds, &c., taken from the fields. The breeder even feeds selected cattle with ripened *jowar* heads and *mug* plants. Cattle are taken back to the villages just at sunset.

The animals are housed in fenced open yards in summer and in thatched huts in winter. The cows are always kept separate and are attended to separately from the male stock, and the bull is kept away from the bullocks. The calves are kept in front of the owner's house in summer and in one corner of the house in winter.

#### REARING OF THE CALVES.

Great care is taken in the rearing of the calves. They are allowed to suck one teat of their mother in rotation at each milking for the first fortnight or one month according to the mother's yield, two teats at each milking for the next three months, after which they are allowed to take the whole of the mother's milk. In no case are they herded together with their dams till weaned, that is to say, until they reach the age of six months, or of ten months in the case of calves reserved as bulls.

When they are to be weaned, they are offered crushed *jowar* grain and fine *jowar kadbi* fully chaffed, and always green fodder if this is available. They are let out for exercise in the house yard when very young, and when about five months old they are sent out for exercise (once a day, in the morning, for three hours only) with the village cattle to fields adjoining the village.

All animals are watered from the village tank made by bunding up the river. This water is used for household

purposes, and this source of supply, in ordinary seasons, lasts up to March. In May and June there is always acute scarcity of water for watering the cattle and for drinking purposes, and small *katcha* wells are sunk, as already described, in the lowest part of the river bed. The shortage of water at this time of the year is the factor which limits the development of the live stock industry in this area.

#### MANAGEMENT OF COWS.

The following details with regard to the management of the cows may be added to what has been already stated. The foundation stock of the best breeds are looked after like the Arab's mare. The cows are fair milkers, as Indian cows go, the average per day being ten to twelve pounds of milk. It is not uncommon to get cows yielding fifteen to twenty pounds of milk. Though they have good conformation for milk production, they have never been exploited for this purpose. There is no sale of the milk, and no demand for ghee. Therefore only just enough milk is required or taken to satisfy household demands for milk, buttermilk, and butter. As every farmer is a breeder and every *jagirdar* and *sardar* has a herd of his own, and further as there are no *banias* or outside merchants in the villages whose presence would give an impetus to trade in dairy produce, there has been no inducement to work up the cows as milk producers. At the same time, there is evidence that by careful selection good milking strains could be developed.

#### MANAGEMENT OF BULLS AND BULLOCKS.

As already stated, bulls are never let loose with the herd, and are stall-fed. They are exercised in the farmhouse yard when the rest of the herd is out for grazing.

Bullocks are also stall-fed except in the very slack season and when there is scarcity of fodder. They are fed chaffed *kadbi* and other seasonal fodder. They seldom get any other ration. In size they are similar to Nellore or Krishna Valley Cattle, but are not as heavy and slow as the latter. They are excellent transport animals, and have been used extensively for heavy draught including the drawing of siege trains for military purposes, and also as pack animals. They are not as fast as Gujarat (Kankrej) bullocks, but in heavy work they do not lose condition like the latter, and they are not so nervous and timid. As there is a steady sale for the bullocks, they are rarely maintained for more than

three years. The export is not, however, as great as formerly owing to the introduction of mechanical military transport, higher railway freight, and greater difficulty in getting passes to sell.

#### GENERAL FODDER SUPPLY.

Provision for fodder supply in the hot weather is made by stacking *jowar kadbi* as a reserve to last for three to five months. If there is a failure in the floods in the Nari river, or in the rains in the valley itself, a serious fodder famine occurs. Such scarcity of fodder, coupled with no drinking water, drives the people out, and they, with their best animals, migrate to the Upper Sind Frontier and Larkana Districts of Sind, returning when normal conditions again prevail. They never, however, sell their animals in Sind or settle there. These periodic scarcity of fodder and water has, in fact, the effect of weeding out the inferior animals and thus assists in maintaining the quality of the stock.

#### CATTLE DISEASES.

Owing to the isolated character of the Kacchi tract and the rare introduction of outside animals, cattle diseases are not very prevalent among the Bhagnari cattle in their home. Contagious diseases do, however, occur. Foot and mouth disease, so common throughout India, is also found here frequently. It usually appears in the hot weather, but cases are known in winter. It varies much in virulence, but causes no mortality, though it damages the animals seriously. They become emaciated, and working bullocks are debilitated and are incapable of work for a month on account of sore feet. The method of treatment locally adopted is to make the animals stand in hot sand or in mud, or else kerosene is applied to the sore feet. The sores on the mouth are rubbed with soft warm *jowar* bread.

Other diseases occurring sporadically, and more or less frequently are black quarter, anthrax, and hoemorrhagic septicæmia. Rinderpest occurs at intervals and seriously about once in four years, but is not so frequent as in other parts of India. The mortality is, however, severe and there is no substantial remedy known to the people.

It is probable that the mortality from diseases is much less than in the British districts of the Bombay Presidency, but there are no reliable figures available.



## CATTLE TRADE.

It is very difficult to find the extent of the trade between the Kacchi tract and outside centres like the Upper Sind Frontier District, and the Larkana District, both of which adjoin the area. This is because no records have ever been maintained by the State, or the Sardar and Jagirdar. Dealers from other parts of India, especially from Sind, the Punjab, and Quetta visit the local markets of the tract or *piris*, at various breeding centres like Taj, Dandor, Mian Takri, Chisti and Chandor in Bala Nari and Tangote, Chalgari, Bhatti Band and Munjhu in Zarin Nari. The cattle bought are either taken away by rail or by road, the markets being chiefly held between January and March. Many animals are, however, brought for sale to the horse and cattle show at Sibi in December, and a number are even seen at the weekly markets in Jacobabad.

Further cattle are often smuggled through by road to adjoining parts of Sind, with the assistance of the local people. Such animals are of course, cheaper than those exported with State permission, as there is said to be often some difficulty in obtaining the necessary leave to export. Occasionally, in times of real or reputed fodder scarcity, the breeders themselves drive their cattle down to Sind in order to get food for them, when these may be sold to Sind traders dealing with the Punjab and adjoining areas.

The chief stations for the export of Bhagnari cattle by rail are Lindsay, Nuttal and Belpat, and the following figures of animals exported from these stations for two consecutive years have been supplied:—

*1st year.**Lindsay Station—*

(1) to the Punjab (Shershah, Chacharan, Gojra and Lahore)	... 226 animals.
(2) to Quetta	... 10 animals.

*Belpat Station—*

(1) to the Punjab (Multan, Shujabad).	30 animals.
(2) to Jacobabad	... 30 animals.

*2nd year.*

*Lindsay Station* to the Punjab and Quetta. 570 animals.

*Belpat Station* to the Punjab and Quetta. 210 animals.

*Nuttal Station—*to the Punjab and Quetta. 38 animals.

These figures give an idea of the extent of the trade by rail, but private inquiries showed that two hundred or more animals get to the Upper Sind Frontier District by road. Most if

not all such road-imported animals were purchased by small holders or tenants and not by the land-owning Sardars. They were then worked up to the end of the following *kharif* season and then were brought to market in good condition and in many cases sold to Punjab dealers. Few good animals were retained by the Zemindars of Upper Sind.

It must again be insisted on that all these animals sold to Sind or the Punjab were bullocks. No bulls or breeding cows are sold.

*Bhagnari Cattle in Upper Sind.*

Three Sardars of the Upper Sind Frontier and the Larkana Districts have herds of thirty to forty cows, with two bulls. Two of these which are very well known are those of Khan Bahadur Bahadur Khan Khoso, and Ghaibi Khan Chandio. As a result of the presence of these herds it is not uncommon to see a few good cows of this breed in villages in Upper Sind, but the breeding is in no case in an organised condition in the villages. The animals of the former gentleman mentioned above, and of his son, are in no way inferior to those seen in the original home of the breed. There is in fact no foundation for the popular belief in Sind that Bhagnari cattle of the original standard cannot be bred outside the Nari tract. The simple fact is that while the people of Upper Sind do appreciate the better features of the Bhagnari bullocks, their better size, power and working qualities, they are not prepared to give the same attention to breeding, rearing and general care as is given by the Nari people. Hence it is supposed that the Bhagnari cattle degenerate when they are brought to Sind. But even such degenerate animals are much superior to the ordinary local Sind Cattle.

Every Sind cultivator, be he a landholder or a tenant, prefers to get his cows mated with a Bhagnari bull if one is available within a few miles. One Government bull formerly kept by the Veterinary Department at Kandh Kot in the Upper Sind Frontier District seems to have produced wonderful progeny. Over forty animals, said to have been produced by him, which were examined, showed that in eighteen months to two years the young stock attained the size of their dams. Every young animal was better boned, strongly muscled and active. None of the female progeny of the bull in question were found that had come into milk, but the owners expected an increased milk yield from them. A higher price was expected both for bullocks and cows. The bull in question

was in great demand, and its condition showed that it had been used heavily and recklessly for service. There were many inquiries as to why the supply of such bulls was discontinued, and there is no doubt that the re-establishment of some such premium bulls would be strongly supported.

As already stated, there is a feeling that pure Bhagnari cattle do not do as well in Upper Sind as in their home in the Kachhi District. There does not seem, however, any justification for this position, and it seems certain that they will be a certain success in the Upper Sind Frontier District, in those parts of the Larkana District with Ghabi Dero as the centre, and in the Sukkur District. Breeding elsewhere is not such a certain success, but it may be noted that a Bhagnari bull is now serving in Lower Sind under the auspices of Dr. Asudamal of Hyderabad, on the land granted to him for cattle breeding, but the results are not yet available.

#### SUMMARY.

From the account given it would appear that the character of the land and climate in the Kachhi District, the home of the Bhagnari breed, does not differ materially from that of the Upper Sind Frontier District and of parts of the Larkana and Sukkur Districts. The animals of the breed are liked by the people of Upper Sind and are considered more useful from every point of view,—including both draught and milk,—than the local cattle. As the people of Upper Sind depend on cows and not on buffaloes for milk, the milking capacity is a matter of importance. There is, moreover, sufficient cattle trade at present between the Bhagnari Districts and the British Districts to show that a demand does exist, and that any attempt to make animals of this breed more largely available would be appreciated.

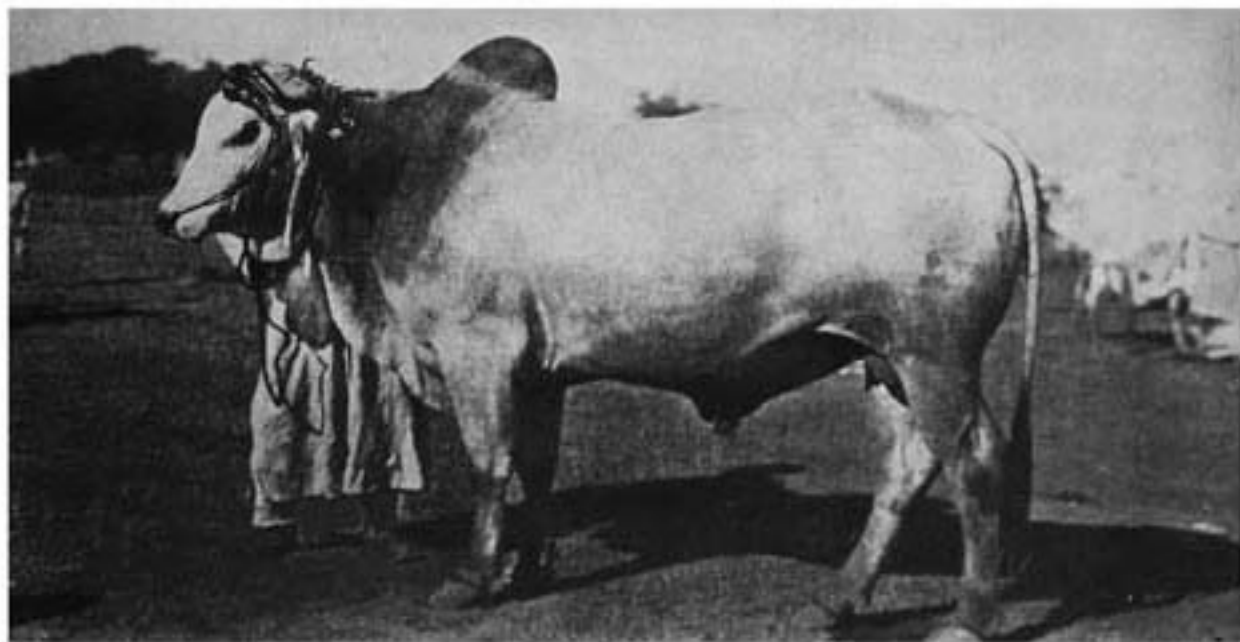
The first step to be taken would seem to be the placing of a number of the best Bhagnari bulls with Zemindars on the premium system, for the purpose of grading up the local cattle. The effect of such premium bulls in the past has been remarkable, and at least half a dozen Zemindars are anxious and ready immediately to start cattle improvement by taking such bulls on the premium system.

The question of starting a farm or farms for the maintenance and improvement of this breed may be considered later. But suitable centres for such farms would be Jacobabad, Larkana or Sukkur.

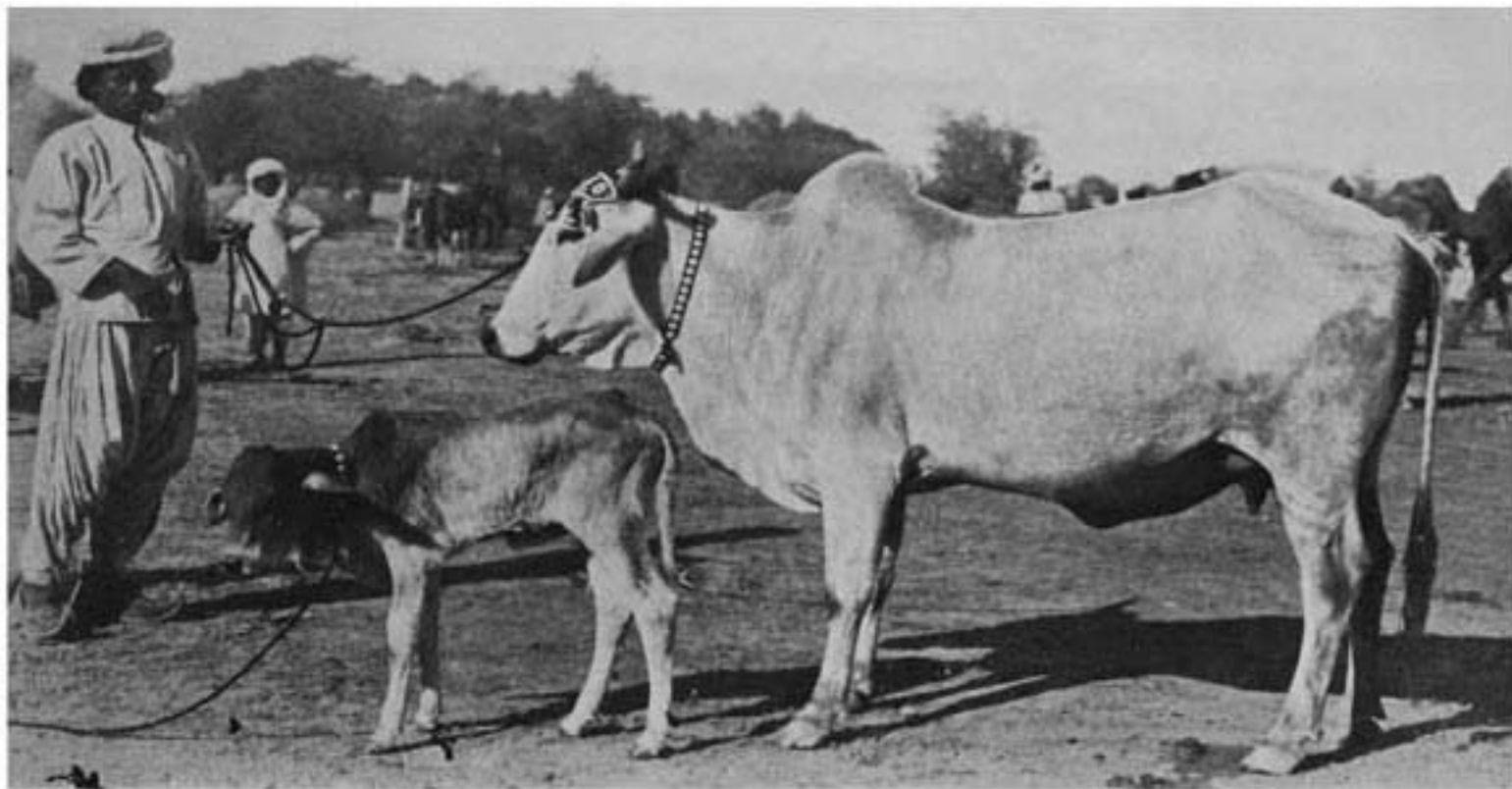
APPENDIX.

Measurements of Bhagnari Cattle in Kaolhi District.

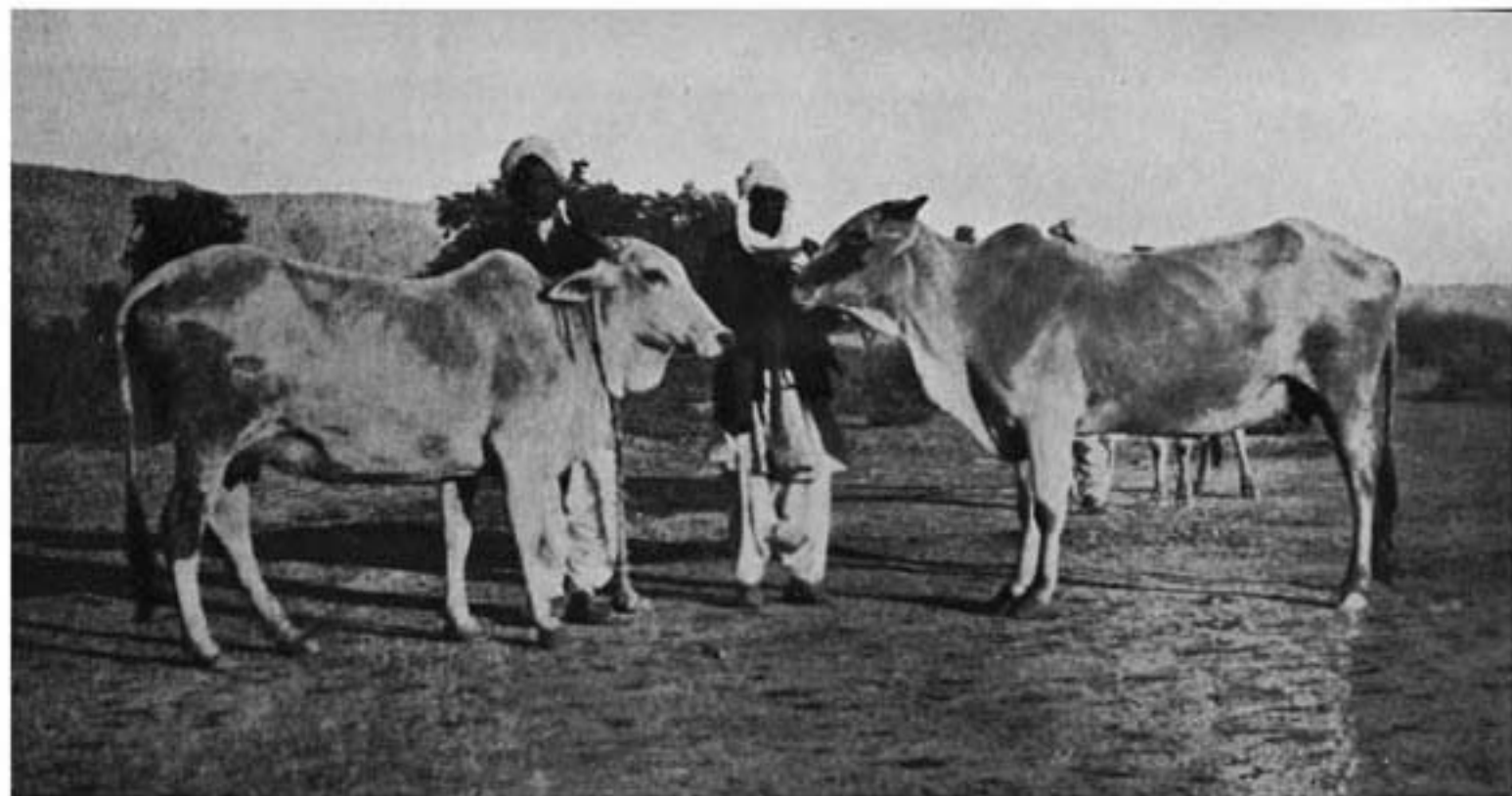
	Height at shoulder.	Height at croup.	Height at elbow.	Length.	Girth at chest.	Girth at abdomen.	Girth at forearm.	Girth at shank.	Length of shank.	Length of horns.	Length of ears.	Length of face.	Breadth of forehead.	Length of neck.
	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.
I. Bulls—														
(a) 2½ years old (average of 2)	52½	55½	30	52½	69	78	15½	7½	6½	1½	10	20½	8½	15
(b) 3 to 3½ years old (average of 6)	52½	55½	29½	52½	71½	82½	15½	7½	6½	2½	9½	20	8½	16½
(c) 4 to 4½ years old (average of 4)	53½	56½	29½	54½	73½	81½	16½	7½	6½	3½	10	20½	8½	16
II. Bullocks—														
(a) 4 years old (average of 4)	50½	53½	27½	52½	71	80½	15½	7½	6½	4	9½	19½	8½	16½
(b) 5 years old (average of 4)	54½	57½	29½	56½	76½	89½	16½	7½	6½	6½	10½	21½	9½	16
(c) 6 years old (average of 2)	54	58	29½	55½	74½	84	16½	7½	6½	5	9	20½	8½	17
III. Cows—														
(a) 3 to 3½ years old (average of 2)	49	51	27½	47½	61½	72½	13½	6½	6½	3	9	18½	6½	17
(b) 5 years old (average of 3)	51½	53½	28	51½	71	86½	14½	6½	6½	6½	10	19½	7½	16
(c) 6 years old (average of 2)	49½	53	28	53	66	84	14	6½	6½	6½	9½	14½	7½	15½
IV. Bull calves—														
(a) 10 to 14 months old (average of 3)	48½	50½	27½	47½	62½	69½	14½	6½	6	1	9	17½	9½	14½
(b) 15 months old	50	53	29	50	64	72	14½	6½	6½	1	10	18	7½	15
(c) 2 years old (average of 3)	52½	56	30½	53	69	76½	16½	7½	7	2	10½	19	8½	16
V. Heifer—														
(a) 18 months old	47	50	27	45½	60	70	14	6½	6½	1½	9	17½	6½	15



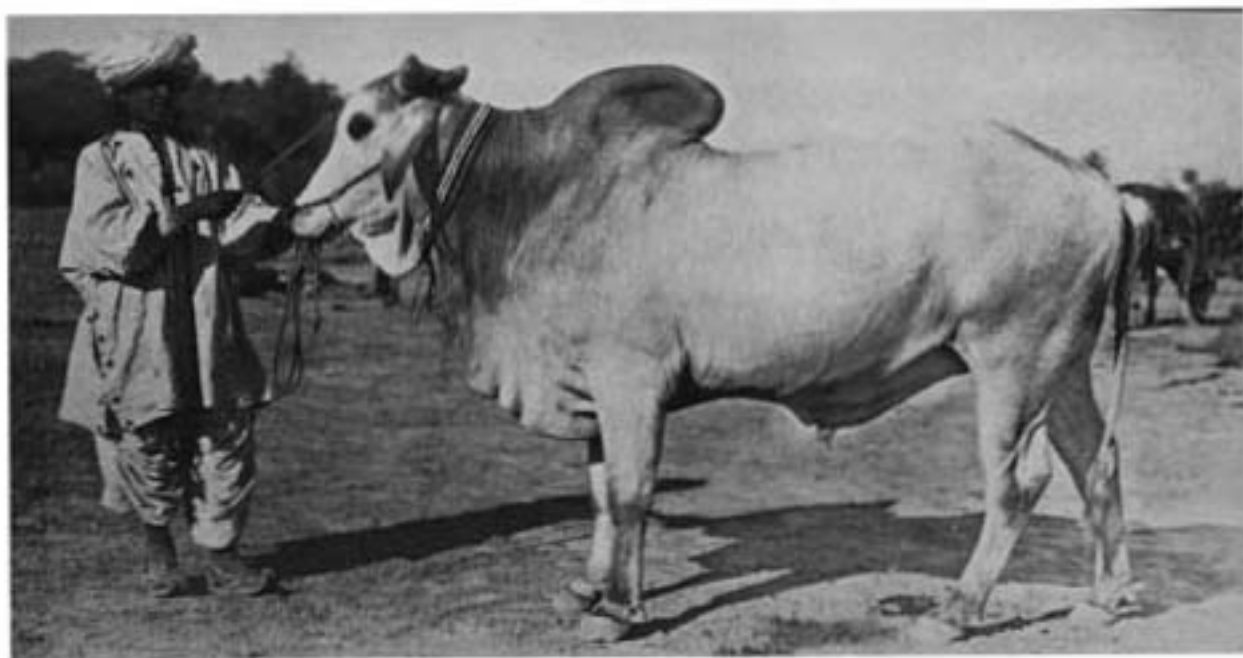
**Bhagnari bull.**  
**Height 57". Girth 83". Weight 13 cwt.. Age 5 years.**



**Bhagnari cow.**  
**Height 45". Age 5 years.**

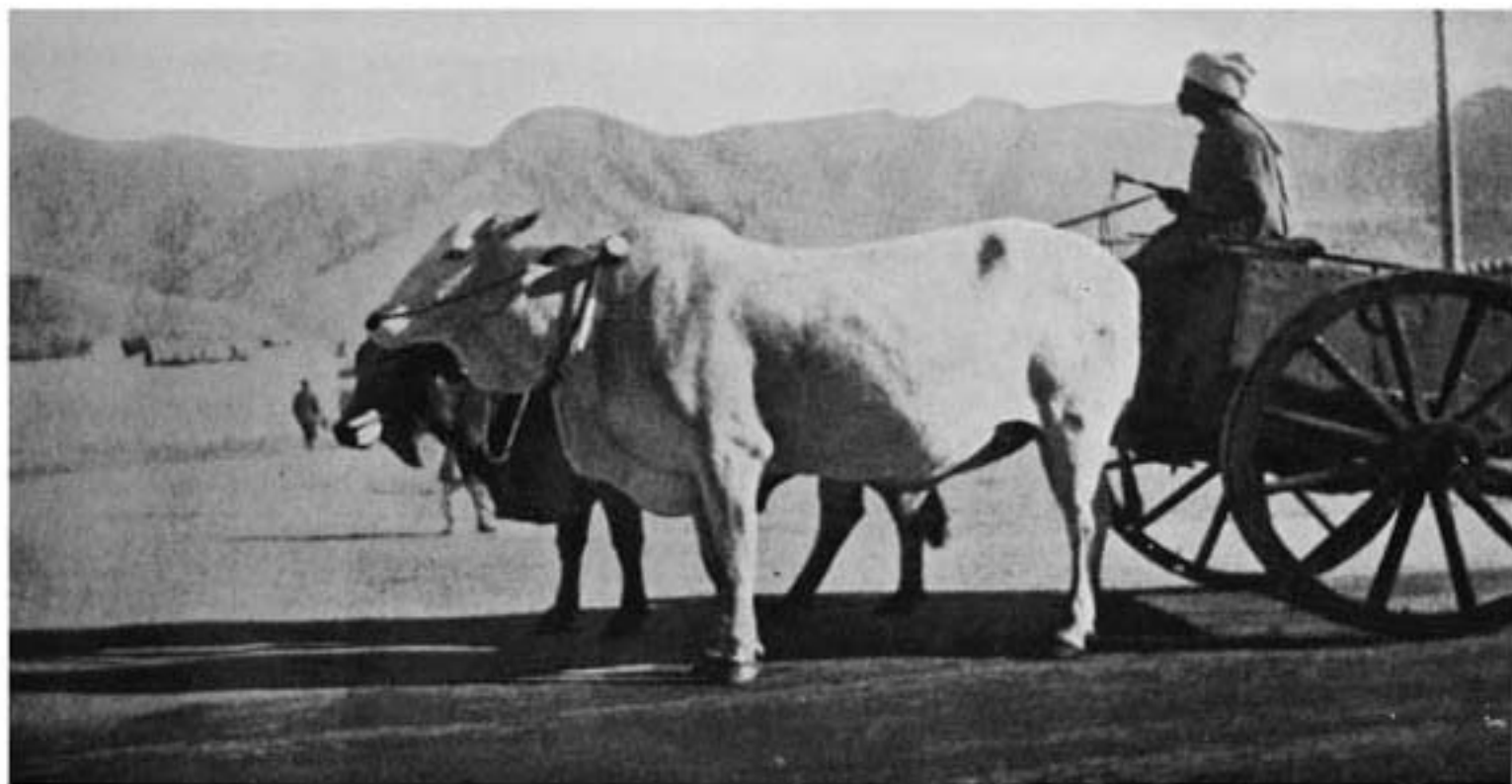


Two young Bhagnari cows.



Bhagnari bull,  
Height 54", Girth 72", Weight 11 cwt., Age, aged.





**A Pair of Bhagnari bullocks.**

## ELEPHANT GRASS.

### A New and Useful Fodder Crop in Western India.

On the whole we are well off in Western India for fodder crops, but there is need of additional perennial grasses which will grow vigorously on relatively poor soil and give large yields of palatable green fodder per acre. To a certain extent guinea grass satisfies this purpose, but this rapidly ceases to give large yields unless very well manured, and its demand for irrigation water is great. Rhodes grass also serves the purpose to some extent, but again this needs much manure and water to give the best results. In about the year 1913, a South African grass was brought to the notice of the public which seemed likely to serve the purpose needed in Western India. It received these various names: Elephant Grass and Napiee's Fodder among others, and it attracted attention in the first instance by the way in which it remained green when other grasses became brown, and by the way in which it was relished by stock. Its botanical name, *Pennisetum purpureum*, indicates its close relationship to our common *bajri* crop (*Pennisetum typhordeum*).

Sets of this grass were imported into Bombay in 1915\*, and it has now been grown at several centres in Western India since that time. These centres include the Agricultural College Farm, Poona, His Excellency the Governor's Dairy Farm, Ganeshkhind, Kirkee, and on the Sewage Effluent Farm at Hadapsar in the Deccan, the Chharodi Cattle Farm in North Gujarat, and the Willingdon Cattle Farm near Karachi in Sind. The general results have been so satisfactory that it may be taken that it is likely to be useful over a much wider field, and hence the issue of the present bulletin.

#### Elephant Grass on the Agricultural College Farm, Poona.

This grass was first planted at the Agricultural College Farm, Poona, under irrigation, and in 1918-19 gave 28,000 pounds of green fodder per acre in three cuttings, in 1919-20 43,840 pounds per acre in four cuttings. These figures seemed promising, and a larger area was planted at the end

\*For an account of early experiments, see Bulletin No. 100 of the Department of Agriculture, Bombay.

of the *rabi* season of 1921-22, on ridges three feet apart. It was manured in the following June (1923) at the rate of 20 cart loads (about 16,000 lbs.) of well rotted farm yard manure. It has been regularly irrigated at intervals of ten days throughout the year in the furrows between the ridges, and has been standing on the same land since 1922.

In 1922-23, the crop gave three large cuttings, and a little beside. These cuttings were as follows:—

July 25th, 1922 ... 12,300 lbs. per acre.

October 20th, 1922 ... 12,000 lbs. per acre.

January 26th, 1923 ... 11,415 lbs. per acre.

The total yield for the year was 36,350 lbs per acre.

The same plot of Elephant grass, in the year 1923-24, gave cuttings as follows:—

July 4th, 1923 ... 14,870 lbs. per acre.

August 25th, 1923 ... 8,170 lbs. per acre.

January 28th, 1924 ... 4,000 lbs. per acre.

The total yield was thus 27,040 lbs. per acre.

The same plot in 1924-25 gave two good cuttings but the third, which would have taken place in January 1925, was destroyed by the frost which occurred during that month. The grass is in fact, very sensitive to frost, though the roots do not appear to be damaged. The yield in this year was as follows:—

July 15th, 1924 ... 11,670 lbs. per acre.

November 25th, 1924 ... 11,070 lbs. per acre.

Thus, owing to frost, the yield in 1924-25 was only 22,740 lbs. per acre.

The fact that the root stocks were not seriously injured by the frost is shown by the cutting of 12,500 lbs. of green fodder obtained on July 11th, 1925.

The grass though apparently coarse was readily eaten by working bullocks, though these preferred guinea grass.

#### **Elephant Grass on the Sewage Effluent Farm, Hadapsar.**

Elephant grass was planted on the Effluent Farm, on medium black soil, 18 inches deep with a porous *murum* sub-soil. It was originally put in the last week of December 1918, the sets being planted on ridges 30 inches apart, 30 inches being also kept between the plants on the ridges. It has been regularly irrigated with effluent mixed with water containing about one part nitrogen per 100,000 points of mixture. In all

about twenty waterings were given each year, each watering being equal to about  $2\frac{1}{2}$  acre inches. In the cold weather only one watering in 30 days has usually been given.

The grass has grown well from April to October. From November to March there was practically no growth. It was usually cut when it reached the height of four feet and generally gave three to four cuttings per annum. The actual yields per acre of green fodder in the years since planting were as follows:—

1919-20	... 81,240 lbs.
1920-21	... 103,280 lbs.
1921-22	... 114,840 lbs.
1922-23	... 121,680 lbs.
1923-24	... 125,700 lbs.

These yields are very high, but it must be remembered that they are obtained with sewage effluent. They show, however, what the grass will yield under favourable conditions.

#### **Ganeshkhind Dairy Farm.**

The fodder grass under discussion has grown very well on this farm, but unfortunately records of yield have not been kept. The Manager, Mr. E. Little, has given me his experience, however, with it as follows:—

“During the present season (rains 1925) it grows to a height of about  $5\frac{1}{2}$  feet in two months, with established plants, and during the hot season it takes about three months to grow so high. The cattle all eat in with relish, and I am inclined to think it would be an excellent crop to plant on dirty land, as it appears to stifle most other grasses and weeds once it has become established.”

#### **Chharodi Cattle Farm, North Gujarat.**

The records so far given are from the Deccan. The grass has recently been tried, however, in the alluvial tracts of North Gujarat, being planted on the Chharodi Farm (Ahmedabad District) on July 23, 1923. Ridges were prepared four feet apart, and sets, four to six inches long, were planted three feet apart on the ridge. Irrigation was given about every ten days in the furrows. The first cutting was taken on October 6, 1923, or about  $2\frac{1}{2}$  months after planting, and yielded 7,744 lbs. per acre. A second crop was taken after a month and yielded 1,248 lbs. per acre. And a third

cutting a month later, yielding 1,728 lbs. per acre. Thus 10,720 lbs. per acre were obtained before the end of March 1924. In the year 1924-25 (April 1924 to March 1925) a yield of 40,480 lbs. per acre was obtained in six cuttings.

During the early stage of the crop, weeding was done as needed. Interploughing has been done at intervals since that time, and cattle manure was spread between the ridges about twice every year. The general growth was good, and the plants become very full of tillers and hence very bushy. It has been generally cut when it attained a height of four feet. It grows well in the hot weather though not to its full height, and it requires much irrigation. So far (1925) the area has shown no sign of needing renewal.

The cattle have eaten the grass readily, but it is not appreciated as much as most other green fodders, *jowar*, maize, guinea grass, &c., when these are available.

#### **Willington Cattle Farm, near Karachi, Sind.**

Elephant grass has only been planted in Sind in the latter part of 1924 (October) and so figures of yield are only for a very limited period. The impression created has, however, been so favourable that the area is being extended, and it seems likely to be an important fodder in the Karachi District, and possibly in other parts of Sind, in the future.

The best time for planting sets seems to be from the middle of August to the middle of October. These are put in three feet apart each way, and the first cutting is obtained three months later, but the amount of growth depends very much on the temperature. A cutting can be obtained every six or seven weeks after this, except in the very cold weather or when there are very hot winds. In the hot weather it stood well on the whole, but the colour of the leaves changed to red. It grows to a height of three to four feet in this time.

As to irrigation, in these Karachi experiments, it has been found that compared with many grasses it resists drought to a considerable extent. Irrigation for most crops in the porous soil in the Malir area near Karachi has to be repeated every ten days, but Elephant grass has been found to give constant growth when it is watered once every twenty days,—a period hitherto unknown for day fodder crop in this area.

The actual cuttings of grass obtained between the planting in October 1924 and August 1925 were as follows, and indicate what may be expected of this fodder, in the neighbourhood of Karachi:—

1. January 1925	...11,750 lbs. per acre	(weather very cold)
2. February	... 9,500 "	," (weather very cold)
3. April	...16,500 "	," (weather fair, not hot)
4. May	... 6,000 "	," (weather very hot)
5. June	...23,500 "	," (weather exceedingly hot)
6. August	... 4,500 "	," (weather hot)

Total for 8 months ... 71,750 "

#### General Conclusions.

It would seem, therefore, as a result of these tests that we have, in Elephant grass, a crop which can give very high yields of a nutritious fodder, which, while not so palatable as some other grasses (green *jowar*, maize, or guinea grass, for example), promises to occupy a very useful place in the fodder supply of Western India, in the black soils of North Gujarath, and at least in the more porous soils of Lower Sind.

A limited number of sets are now available from the Poona Agricultural College Farm, and multiplication from these can be made very rapidly. In Rhodesia it was found that two roots planted on April 17th gave 224 separate plants on December 7th of the same year.\* So that now it is proved to be of value, multiplication ought not to be a serious difficulty in the way of its rapid extension.

The experience cited above all concerns the growing of Elephant grass under irrigation, but the Karachi experience seems to show that it needs less frequent watering than other similar fodder grasses. It has been planted with success in March or December at Poona, in July at Chharodi, and in October at Karachi. In all cases, the sets were planted on ridges which were spaced at various distances from 2½ to 5 feet and the plants on the ridges were put in from 2½ to

\* Rhodesia Agricultural Journal, Vol. XIII (1916), page 87.

3 feet apart. Irrigation was done (after the plants had rooted) in the furrows between the ridges, where also any cattle or other farm yard manure can be profitably placed and worked into the soil with an interculturing implement. The plants soon form many side tillers, and become bushy, rapidly filling the intervening space. A crop can usually be taken within three months of planting; and then at intervals of from one to three months according to the conditions of growing. It has been usual to cut it when four feet high or over.

The only danger to the crop which has been found here is frost, though very cold weather and very hot winds both prevent its growth. Frost, however, spoils a standing crop, though the amount of frost usual in Western India has not, in any case, injured the stand of plants. In the very hot weather, the foliage becomes red in colour. No pests or diseases have been noticed to attack the grass.

As already stated, all the experiments above recorded have been under irrigation, and it is not likely that it will stand the *long* droughts that are usual in most parts of Western India. It may be noted, however, that it is considered as drought resisting in South Africa, and large crops were obtained with a rainfall of 21 inches.\* In one experiment in Rhodesia, rooted cuttings planted on a dry ridge, made good growth, though the rain after planting was less than 12 inches in the first season.†

Similar has been the experience in Florida in United States, where it is stated to be a rank vigorously growing grass, six to twelve feet high, which can be propagated by seed, root divisions or cuttings. (We have, however, never used the seed here.) It is stated to do best in moist fertile soil, but grows fairly well on rather poor land, and is considered to be drought resistant.‡

As regards the fodder itself, the fresh green fodder gave the following figures on analysis:—

Water	...	61.81 per cent.
Ether Extract (oil, &c)	...	0.29 "
Proteids (Nitrogen 6.25)	...	2.92 "
Digestible Carbohydrates...	...	17.29 "
Woody Fibre	...	14.77 "
Ash	...	2.92 "
Total	...	100.00

\* Rhodesia Agricultural Journal, Vol. X (1913), Nos. 3 and 6.

† Rhodesia Agricultural Journal, Vol. XIII (1916), page 87.

‡ Florida Agricultural Experiment Station Bulletin No. 153 (1919).

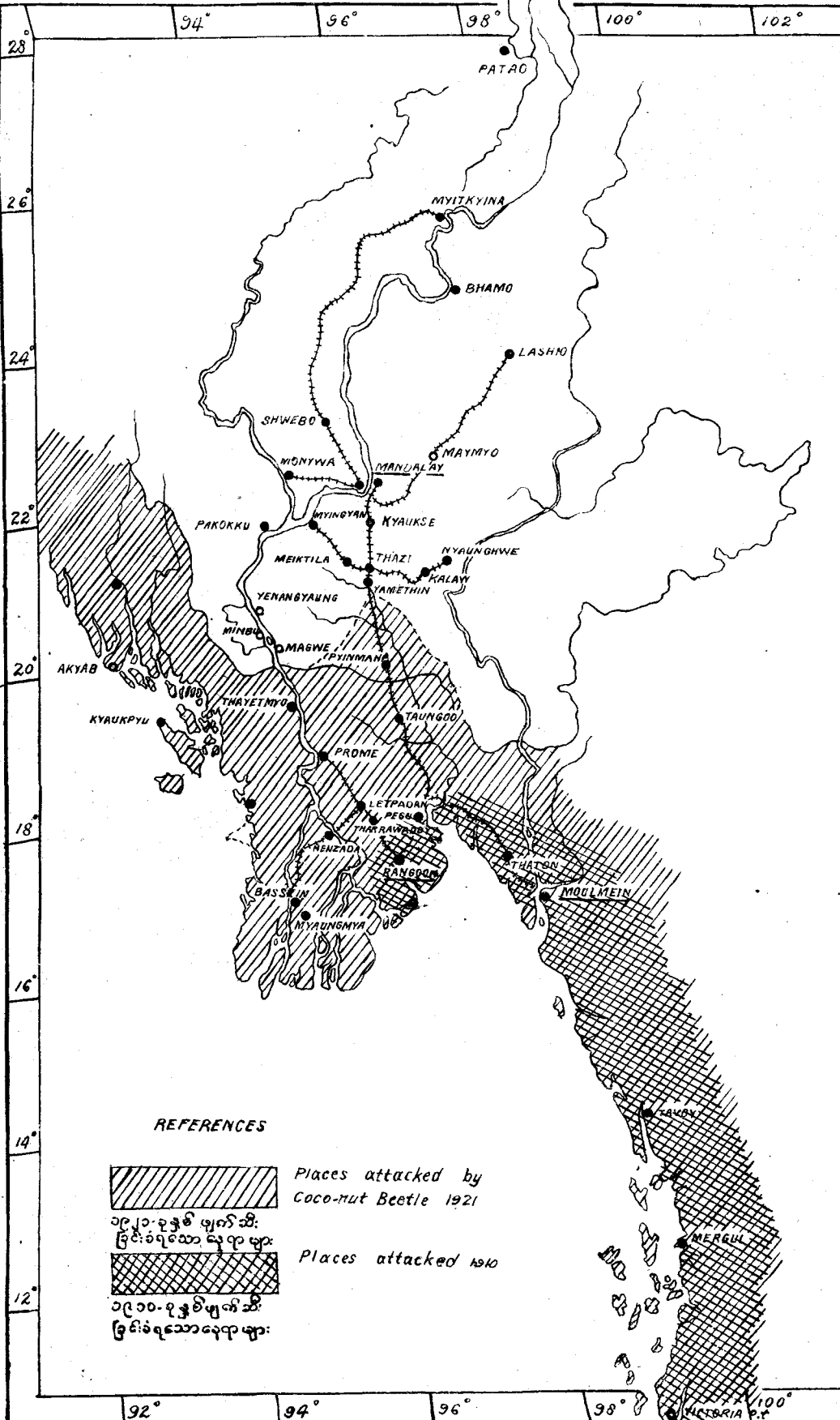
This shows it to be a somewhat fibrous grass, and there seems no doubt that, here, while it is palatable to stock, yet it is rejected in favour of green *jowar*, maize, or guinea grass. In South Africa, it is claimed that it is highly relished by cattle, and this is confirmed from Florida, provided it is well harvested. In other words, it rapidly becomes woody if allowed to stand too long without cutting. Experiments have been made in Queensland as to its suitability for making paper, and it has been recommended as likely to be useful for the more expensive kinds of paper.\*

Finally, it seems that we have in this grass a plant which is worthy of consideration as an addition to the fodder resources of Western India, and which should be tried as a perennial, heavy yielding grass, using a limited amount of water.

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\* Queensland Agricultural Journal, Vol. XVI (1921), page 8.





REFERENCES



Places attacked by  
Coco-nut Beetle 1921

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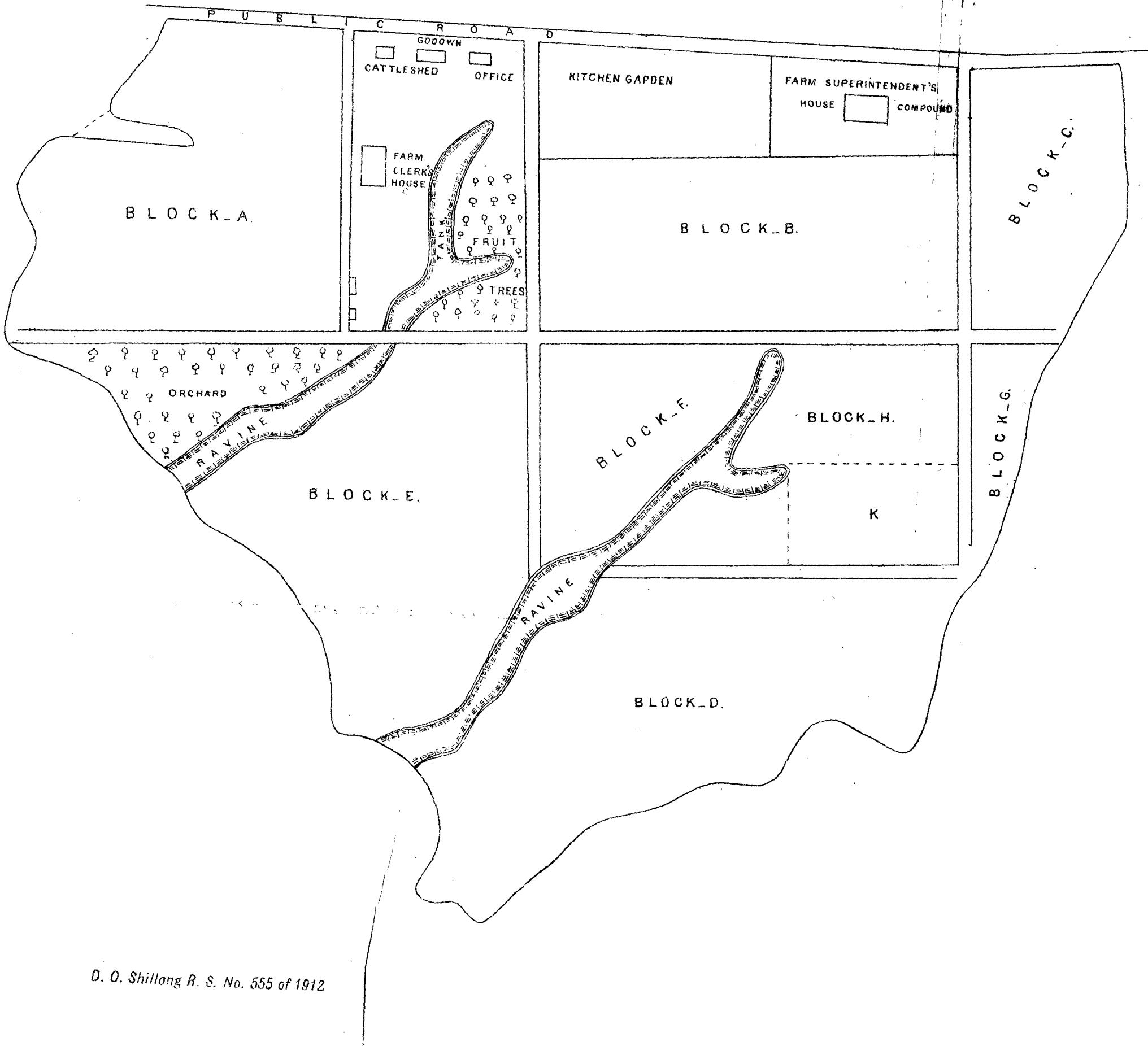
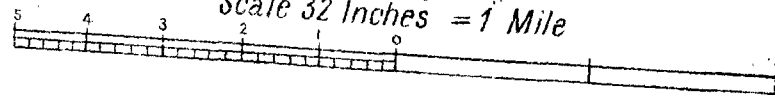
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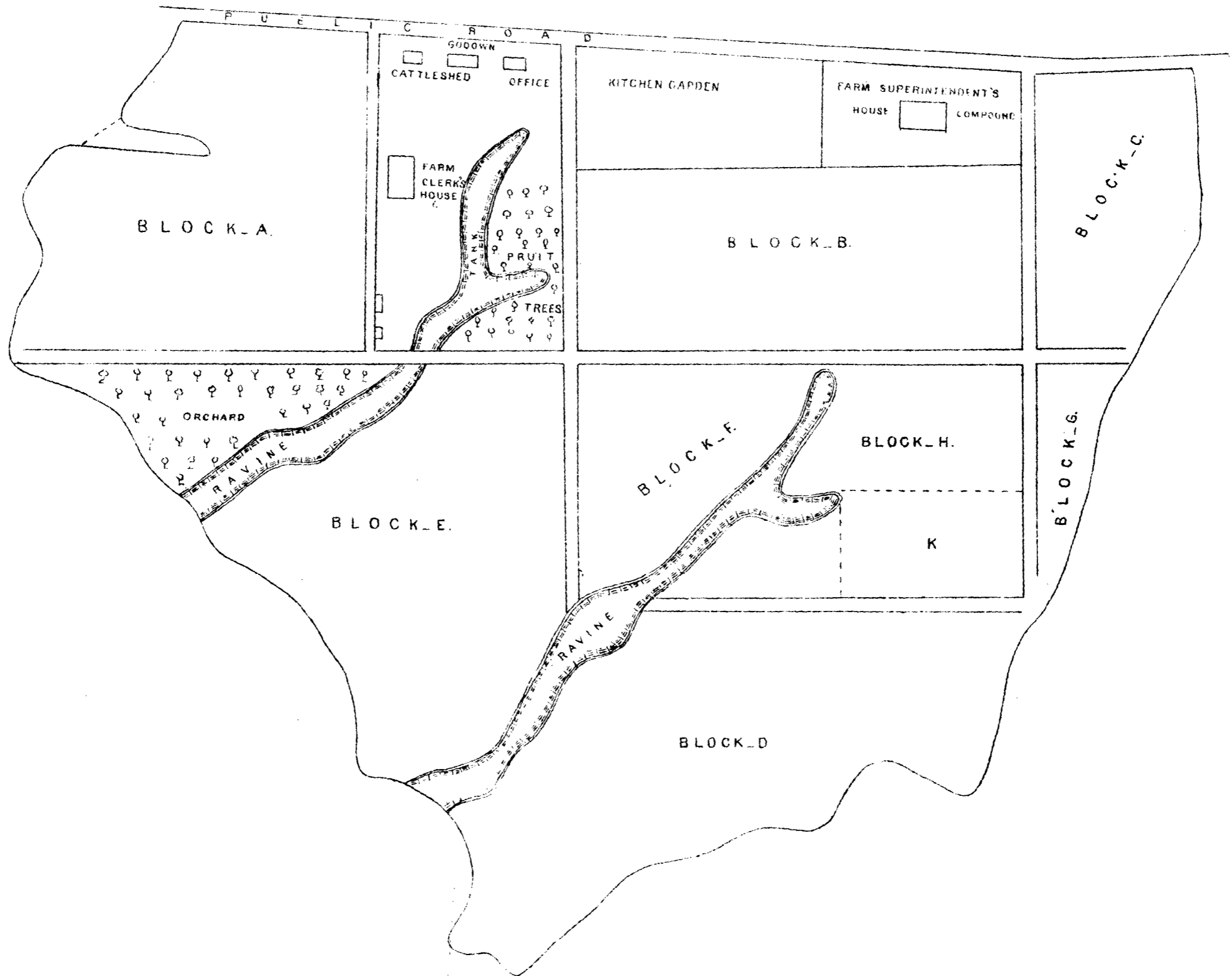
# MAP OF JORHAT FARM

Scale 32 Inches = 1 Mile



# MAP OF JORHAT FARM

Scale 32 Inches = 1 Mile



# THE KACCHI COUNTRY BALUCHISTAN THE HOME OF THE BHAGNARI BREED.

