## 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 iowar. 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 kadbi. 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 (Borchay Presidency excluding Sind).
	Acres.
1907-08	26,419
1908-09	. 20,766
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	Area under fodder crops (Bombay Presidency excluding Sind). Acres.
1000 10	
1909-10	21,206
1910-11	21,652
1911-12	64,216
1912-13	96,984
1913-14	79,221
1914-15	108,793
1915-16	79,926
1916-17	118,109
1917-18	99,545
1918-19	110.013
1210-12	

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 few years : nine-tenths of the acreage given is in the one district of Thar and Parkar.

Area under fodder crops (Sind).

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		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
1915-16	••	9,693
1916-17	• •	37,568
1917-18	• •	17,847
1918-19	• •	12,439

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 :----

The crops must be palatable, digestible and not 1. 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 repsesents 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; 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 quanitty 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 conditions 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), place side by side with the

District.	:	Talukas,		Average Rainfal	1.	Percentage of total cul- tivated area under jowar.	of cereal
				Inches.			
•	(	Haveli	••	31.9 (Poona)		14.1	28-9
Poona	- )	Sirur		21.7		25.9	39.1
oona	)	Bhimthadi		23.3		39.8	60.2
	(	Mawal	••	42°5 to 186°6		3.4	9.1
Sholapur	••	(The whole district)		22 to 26		39.5	69.5
East Khandesh		(The whole district)		23 to 31	• •	18.0	51.3
	1	Belgaum	•••	51 '9 (Belgaum)'		7.4	17.2
Belgaum		Khanapur		71-1 (Khanapur)		2.3	4.0
beigaum	)	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.

rainfall in various talukas of one or two districts, and in the whole of other districts in the Bombay Presidency \* :---

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 subtropical 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

<sup>\*</sup> Statistical Atlas of the Bombay Presidency, 1906.

almost any other cereal crop which has been tested. The latest comparative tests of this with other 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		lbs.
Oats	604	,,
Barley	513	,,
Maize		,,
Jowar (Sorghum)	306	,,

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

Wheat	
Oats	469 "
Barley	468 "
Maize	337 "
Jowar	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.

<sup>\*</sup> 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).

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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) Imphi.—The glumes are black and the head, on the plant, is drooping.
      - (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.

<sup>\*</sup> A more complete classification of the Bombay jowars is given in Bulletin 92, Bombay Department of Agriculture (1919).

# (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 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

<sup>\*</sup> Mollison—Poona Farm Report, 1893-94.

<sup>†</sup> Quoted from Leaflet No. 6 of 1909 of the Bombay Agricultural Department.

<sup>‡</sup> Pennisetum typhordeum.

<sup>§</sup> Panicum Scrobiculatum.

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 Bornbay 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 Guiarat.—So far as Northern Gujarat is concerned Mollison<sup>†</sup> 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 triffing. 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

<sup>\*</sup> Mollison-Text-book of Agriculture, Vol. III (1901), page 14.

<sup>†</sup> Poona Farm Report, 1900.

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 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 cut- ting.	Cost of per acre.			Yield of dry fodder per acre.	
1912.		Days.	Rs.	a.	р.	lbs.	
August 5th	None.	61	11	8	0	5,040	
September 1st	None.	52	12	0	0	2,912	
September 15th	Irrigated twice.	63	34	0	0	3,856	
October 1st	Do.	58	42	0	0	3,008	
October 15th	Irriagted three times.	66	59	8	0	2,432	

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

\* Nadiad Farm Report, 1912-13,

Date of sowing.		Irrigation.		Time between sowing and cut- ting,				Yield of dry fod- der per acre.	
1913.	•			Days.	Rs	a.	p.	lbs. 6,760	
August 22nd		None.		55	27	12	0	3,880	
September 22nd		Irrigated five times.		55	57	0	0	· <b>4,4</b> 00	
October 16th		Do.		64	51	0	0	2,000	
November 15th	••	Do.		74	51	8	0	2,000	
December 15th	••		Fa	iled.	(				
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	

These results were carried further in the following year and the following figures were obtained\* :--

The average outturn<sup>\*</sup> 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.

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

<sup>\*</sup> Letter from the Superintendent of Nadiad Farm,

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 ninetees 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

<sup>\*</sup> Surat Experimental Farm Report, 1913-14,

by 24 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.
1893          1894          1895          1896          1901          1902          1903          1905          1910	8,320 pounds. 11,896 do. 8,960 do. 11,700 do. 3,846 do. 4,910 do. 6,058 do. 6,960 do. 8,436 do. 13,464 do.	$\begin{array}{cccccccccccccccccccccccccccccccccccc$	75 0 0 107 0 0 69 0 0 91 0 0 30 0 0 38 0 0 45 0 0	Spoilt by continuous rain in July.

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 41 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 sugarcane, during the rainy season without any irrigation, *sundhia* gave a yield of green material equal to 8,512 pounds of dry fodder<sup>†</sup>.

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<sup>\*</sup> Poona Farm Report, 1896.

<sup>†</sup> Report for 1904 of Manjri Farm.

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	3 cuttings, 43, 89 and 153 days.	lbs. 12,756
August 22nd September 9th	times. Do. Irrigated seven times.	2 cuttings, 50 and 122 days. 2 cuttings, 62 and 146 days.	7,788 9,032

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\* :---

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

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<sup>†</sup>. It is written as applying to sundhia, nilwa 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 favourabe 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 the first week in October, which proved rather inconvenient monsoon was not over and the kadbi could not be dried up 1....

> s present information goes, therefore, sundhia post suitable fodder crop in the more genens in the south of the Bombay Presidency.

> > Gilbert, Deputy Director of Agriculture, Dharwar, Report, 1910-11,

### DUDHIA JOWAR.

From the same part of Gujarat as sundhia 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 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.

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

<sup>\*</sup> Poona Farm Report, 1897. † Mollison.

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

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.
Nilwa Sundhia	• •	••	lbs. 6,369 4,411	Rs. 36 30	Rs. 42 34

Nilwa has not been found at all suitable for planting from August to January<sup>‡</sup> 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 Maniris two types of nilwa jowar seed gave the following yields, which are very satisfactory, and it is now recommended as probably the best rotation crop to follow sugar-cane, at any rate near a centre where there is a demand for fodder.¶

<u></u>	 		Yield of dry fod- der.	Cost.	Value of produce.
I II	 ••	••	lbs. 8,512 11,632	Rs. 11 11	Rs. 53 65

\* Mollison-Poona Farm Report, 1897.

Poona Farm Report, 1895.
 Poona Agricultural College Farm Report, 1912-13.
 Manjri Farm Report, 1904.
 Bulletin No. 90, Bombay Department of Agriculture (1918).

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.

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

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 siol and will better resist drought. On the other hand it matures more slowly than sundhia ard 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.

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

<sup>\*</sup> Dharwar Farm Report, 1909-10.

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.
Utavli	7,575
Nilwa	4,846
Sundhia	3,846

	١	lear.		Yield of dry fod- der.	C	ost.		Valu prod		
				lbs.	Rs.	a.	p.	Rs.	a.	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.

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

	Crop.	Date of sowing.	Date of flower- ing.	Number of days from sowing to flowering.
Sundhia Nilwa Utavli		July 15th July 9th July 10th	September 5th September 19th September 13th	72

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 fodger 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.<sup>‡</sup> 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 fod- der per acre.
Hundi	March 28th	Ist crop—May 23rd to June 20th 2nd crop—July 14th to August 14th	lbs. 13,702 10,741
Katbondi	Ápril 10th	lst crop—July 1st to July 13th 2nd crop—No record.	13,463 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 der per		Date of sowing.	Date of cutting.	Cost acr	-	
			lbs.			Rs.	a.	<b>p</b> .
903	••	(Hundi)	8,400	March 28th	May 23rd and July 14th	No re	cor	d.
904		,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,	12,460	April 20th	July 10th	31	0	0
905		••	5,320	March 1st	July 10th	55	0	0
910	••	19	19,300	March	July	144	0	0
912			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. During the famine of 1918-19 *hundi jowar* gave on the whole the best result of all fodder crops in the Deccan when planted after February.

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.

<sup>\*</sup> Information supplied by Mr. G. K. Ranade, L. Ag.

## 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 kmany 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. Thev 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 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.

Ye	ear.		ld of dry fod- per acre.	Date of sowing.	Date of cutting.	Cost per acre.
1906 1910 1911	•	••	l bs. 1,104 3,884 5,540	October	February 6th, 1907 January 1911 February 1912	Rs. a. p. 16 0 0 17 0 0 66 0 0

\* Poona Farm Report, 1904.

† Dairy Farm Report, 1905,

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 specia fodder crop; it is usually allowed to ripen and produce seed the straw (kadbi) forming an excellent dry fodder. But ir a dry or famine year, shalu jowar cultivated for fodder only has in 1918-19 proved itself very disappointing in the Deccan, and very much inferior to maize as an emergency crop in the rabi season. It seems indeed, as if shalu jowan can only grow on land previously saturated to a considerable depth with water. This condition does not occur in a famine year, unless an irrigated crop has preceded it, and it is only in these last conditions that it succeeded well in the severe famine conditions of 1918-19.

### American Sorghums.

Two American sorghums were introduced by the Bombay Agricultural Department about twenty-five 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

<sup>\*</sup> Text book of Agriculture, Vol. III,

with manure, the (American) sorghums will yield as heavily as the best indigenous varieties: but with deficient rainfall, 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.	cr	lue op j cre	per	
1894 1895 1901 1902 1903 1904 1909	•••	(Amber (Collier) (Amber) (Collier) (Collier) (Collier)	12,457 15,385 6,859 6,918 [12,529 [19,903 11,025	Rs. 56 103 46 46 52 84 83 89 36		0 0 0 0 0 0	<pre>} Spoilt by heavy rain in September. (Very dry July). (Do. do.)</pre>

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*,

•	The	following	are	figures

Crops.			Yield of dry fodder per acre.	Value of crop per acre.	
				lbs.	Rs. a. p.
Sundhia-	•••	• ••		4,912	38 0 0
Nilwa	••	••	••	9,109	61 0 0
American son	rghums (1)		••	8,360	56 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.<sup>+</sup>

I have also 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.<sup>‡</sup>

### IMPHI IOWAR.

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

<sup>\*</sup>Poona Farm Report, 1895.

<sup>†</sup> In the Punjab, these American sugar sorghuns have given 13 tons of green fodder per acre under irrigation, equal to say 5½ to 6 tons of dry fodder, see Annett, Pusa Bulletin No. 41 (1914).

<sup>1</sup> Private communication from Rao Saheb G. K. Kelkar,

Year.		dry fodder ci		Value of crop per acre.		Remarks.
		lbs.	Rs.	a.	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	88	0	0	•

1893 in Poona on medium black soil, as a rains crop and has yielded in some years as follows :---

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<sup>‡</sup> 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 '*Fulgar yellow*,' grown near Dharwar. This grows more slowly than

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<sup>‡</sup> See Poona Farm Reports, 1894 and 1895.

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.

Сгор.	•	Yield per acre in green fodder.
Sundhia	••	7,000
Nilva	••	10,140
Utavli	••	18,048
Fulgar yellow	••	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 shalu 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 rains 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) Imphi 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 sixtyfive 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 ]

31	lbs.		20,514 lbs.	
52	,,		22,004 ,,	
80	,,	••	29,531 "	

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)-

of dry fodder per acre.
7,114 lbs.
8,642 ,,
9,994 ,,

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

Sundhia	50 to 60 lbs. per acre.
Nilwa	40 to 45 "
Utavli	40 to 45 "
American Sorghums and	· · · · ·
Imphi	50 lbs. per acre.
Hundi and kalbondi	40
	ne rate as hundi and kalbondi.
Imphi Hundi and kalbondi	

\* Mollison (1. c.)

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 goradu 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 (*kharif*) 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 :--

	Sundhia	32,480 lbs.	of green fod	der per acre.
•	Nilwa	44,716	,,	<b>&gt;9</b>
<b></b> '	American sorghums			
•	(Amber)	55,132		<b>\$</b> 7
	American sorghums			
	(Collier)	54,740	**	<b>,,</b>

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 condition. It should be done in one direction only across the field to make interculture possible<sup>†</sup>. 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.

<sup>\*</sup> See Kelkar-Night soil, a valuable manure. Bulletin No. 34 (1909), Bombay Agricultral Department.

<sup>&</sup>lt;sup>†</sup> 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 filed. The coulters should be about twelve inches apart. Two seed drills should be used simultaneouslyone 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."

40 a (*rabi*) fodde

In the case of autumn (*rabi*) fodder jowar, which is usually either *shalu* or *utavli*, 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 farm yard manure, or poudrette 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 *kharif* 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 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 kalbondi, 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 lossened 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 udid (Phaseolus mungo), chavli or cowpea (Vigna catiang) 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

<sup>\*</sup> Texas Agricultural Experiment Station, Bulletin No. 132 (1910). M A 7-6

proportion of seven parts of sorghum and one part of pulse seea :---

(1) Sorghum and cowpeas .. 3,600 lbs. per acre.

(2) Sorghum and kulthi ... 4,400 lbs. per acre

In pensylvania the average yield of a mixture of sorghum<sup>\*</sup> and cowpeas 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.

<sup>\*</sup> Pensylvania Agricultural Experiment Station Report (1909).

# 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.

<sup>\*</sup> 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 a variety very similar to *nilwa* 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. of young jowar plants.

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 ownex math crop of sorghum vulgare. Exin a few minutes, and many more we rapid administration of purgatives. Dein the monsoon, when the sorghum thus because and the ..... 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 ".\*

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<sup>\*</sup>. 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 :--

<sup>\*</sup>Meagher and Williams—The Farm Manual (Calcutta 1903), page 59. †Nebraska Station Report, 1901.

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

(1) Leather\* (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.

(3) Trumbull (Nebraska, U.S A.)§ found the following quantities of hydrocyanic acid produced by plants in different degrees of vigour. Dark green healthy plants 50 cm. long-01215 per cent.; yellowish green plants 35 cm. long-00499 per cent.; yellow plants only 22 cm. long-00405 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

<sup>\*</sup> Agricultural Journal of India, Vol. I (1900), page 220.

<sup>†</sup> Journal of the Chemical Society, Vol. LXXXIII (1903), page 788.

<sup>‡</sup> Queensland Agricultural Journal, Vol. XIII (1904), page 473.

<sup>§</sup> Nebraska Station Report, 1909.

<sup>¶</sup> Report, Welcome Research Laboratory, Khartoum, 1903-04.

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 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;

<sup>\*</sup> Journal of Agricultural Research, 1915,

(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;

the stalks 1 grains, and the flowers only 0 bed by cattle, states that drying in the sun had no effect on the quantizinal hydrocyanic acid.

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<sup>1</sup> Queensland Agricultural Journal, Vol. XIII (1904), page 473.

<sup>§</sup> Nebraska Station Report, 1909.

<sup>¶</sup> Report, Welcome Research Laboratory, Khartoum, 1903-04.

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<sup>†</sup>" 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.<sup>‡</sup>

"After moving, 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 cover 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 how feet high and four in diameter, of the shape of an old-for the second 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

<sup>\*</sup> Farm Manual.

<sup>+</sup> Farmers' Bulletin No. 50, U. S. A., Department of Agriculture.

<sup>‡</sup> Texas Experimental Station, Bulletin No. 37 (1895),

(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 tips."

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<sup>†</sup>;

> (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;

<sup>\*</sup> Farm Manual.

<sup>†</sup> C. V. Piper-Forage Crops and their Culture, 1914.

<sup>‡</sup> Williams-Farmers' Bulletin No. 50, U. S. A., Department of Agriculture,

(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 as 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.

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

<sup>\*</sup> C. V. Piper Forage crops and their culture, 1914.

<sup>†</sup> Williams Farmers' Bulletin No. 50, U. S. A., Department of Agriculture,

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<sup>+</sup> 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

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

<sup>&</sup>lt;sup>†</sup> The Problem of the witch weed, Department of Agriculture, South Africa Bulletin No. 40 (1913).

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.

The common form of smut in the Deccan and Gujarat 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.

"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  $(12\frac{1}{2}$ *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."

\* Leaflet No. 20 of 1909,

ous damage to *jowars* when grown as fodder crops in estern 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 very similar to (though distinct from) that which does so much damage as the borer of sugar cane. 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. This insect ruined the second or ratoon crop of *sundhia jowar* growing under irrigation at Broach in April and May during the famine in 1919. 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

<sup>\*</sup>For the substance 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.

show signs of dead material at the heart they should be up at once and fed to cattle without delay. This will part prevent the production of the larger second and third brood

The chief difficulty in dealing with the pest is, however, the fact that it attacks other cultivated crops,—*bajri*, maize, and the like

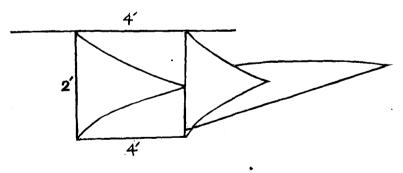
It is, however, a pest which does not lend itself at all easily to direct attack with insecticides or other similar means. It is only by constant watchfulness, by removing plants, especially early in the season, as soon as they are attacked, by avoiding rotations which give constant food for the borer, 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.

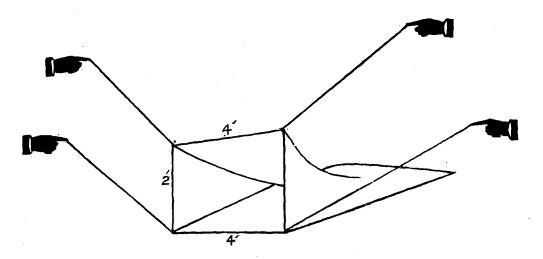
In the second place, the young hoppers can be caught in nets or bags described as follows :--Sufficient strips of coarse country cloth are taken 12 feet long, sewn together so as to make a piece 12 feet long and 6 feet wide. The two ends of this are then brought together and the sides sewn up. This makes 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.  $M \wedge 7-8$  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 aphis 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 :--

	Sun- dhia.	Ameri- can sorg- hum.	}	Hundi.	Utavli.	Shalu.
Water	p. c. 60 <sup>.</sup> 0 0 <sup>.</sup> 6 2 <sup>.</sup> 0 21 <sup>.</sup> 9 12 <sup>.</sup> 5 3 <sup>.</sup> 0	60°0 0°6 1°3 20°1 14°9	60.0 0.6 1.5 20.3	60°0 0°6 2°3 23°5 11°1	0.6 1.4	
*Containing nitrogen	100·0					100·0 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 :--

	-		Uta- vali.	Nilwa.	Khon- di.
Water Ether Extract (o †Albuminoids (i Digestible carbo Woody fibre Ash	.e., nitrogen	 × 64)  	    p. c. 10:0 1:8 6:4 41:9 33:4 6:5	1.5 5.7 41.6 32.8	1.2 5.9 43.5 32.8
			100.0	100.0	100.0
†Containing nits	rogen		 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 sorg- hum in bloom. *	hum seed	Aver- age of 31 analy- ses. t
Water Fther Extract (oil, etc.) ‡Albuminoids (i.e., nitrogen ) Digestible carbohydrates Woody fibre Ash	··· × 6‡) ·· ··	   	p. c. 10:0 5:3 6:2 41:1 32:3 5:1	p. c. 10 <sup>.0</sup> 4 <sup>.5</sup> 4 <sup>.9</sup> 49 <sup>.7</sup> 26 <sup>.3</sup> 4 <sup>.6</sup>	p. c. 10 <sup>.</sup> 0 5 <sup>.</sup> 4 4 <sup>.</sup> 8 49 <sup>.</sup> 9 24 <sup>.</sup> 5 5 <sup>.</sup> 4
<sup>†</sup> Containing nitrogen	••	 • •	100.0	100·0 0·8	100·0 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 anpear- ing). ‡	jowar plants (seeds just
Mositure Ether Extract (oil, etc.) ¶Albuminoids (i.e., nitroge Digestible carbohydrates Woody fibre	 en × 6‡)	· · · · · · · · · · · · · · · · · · ·	••• •• •• ••	p. c. 10.0 3.1 9.0 36.0 31.8 10.1	
		,		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 gramineæ, cut at a similar stage. The material is, in fact, approximately of the quality of maizeder or of good class hay made from grass, cut at flowering. e only objection made against *jowar* fodder is that the joints he stem are hard, and are wasted by the animals. This artly true with the coarser varieties, and when the fodder 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 ders not grow rapidly below about 60°F. but so far as temp for is concerned it will do well wherever the mean is ab Th point (60°F.) during the growing period. As to in a it does not seem to flourish where there is a combins of high temperature and heavy rainfall so far as giving vield 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.

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,

<sup>\*</sup> See Watt-Commercial Products of India-Zea mays.

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<sup>1</sup>/<sub>4</sub> pounds of green fodder.

	Year.		Year. di			d of fod- per production. re.				ue op o ale.		Remarks.	
1893 1894	••	•••	Lbs. 7,940 13,650	Rs. 29 23	a. 0 0	р. 0 0	Rs. 59 94	a. 0 0	р. 0	Green fodder valued at 300 lbs. per Rupee. Green fodder valued at 325 lbs.			
1898 1904 1905	 	 	11,675 8,970 6 300	20 26		000	88 67	0 0	0 0	per Rupee. Affected by long break in rains and therefore irrigated. Hed to be irrigated			
1905 1908	••	••	6,300 9,500	55 34	0 0	0 0				Had to be irrigated.			

These figures give an average yield of 9,700 pounds or about 44 tons of dry fodder per acre on well-manured land. This is just about equal to the yied 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.

<sup>\*</sup> 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.

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

-	Year.	d d	ield of ry fod- er per acre.				ue of op.	Remarks.
1904 1908 1910 1905 1909 1911	   		lbs. 8,700 11,200 10,700	48 151 152	a. p 0 0 d col 0	-	0 0	

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 Nov- ember	7.031
3rd Crop	December to Feb-	7,021 ,,
•	ruary	11,625 ,,
4th Crop	March to June	8,698
	Total	45,662

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

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

During the famine of 1918-19 in the Deccan, maize proved its extreme value as a fodder crop to be sown any time from September on to December. Sown in September it did generally better than any crop, and grew well with irrigation on land which had been quite dry, in contrast with *shalu jowar* which generally failed under similar conditions.

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<sup>+</sup> 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 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.

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<sup>†</sup> Report of the Ratnagiri Agricultural Station, 1913-14.

<sup>‡</sup> Text-book of Agriculture, Vol. III, p. 53,

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.<sup>‡</sup> 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<sup>‡</sup>. The crop is not usually intercultured, if the soil has been well prepared, but

<sup>\*</sup> See, for example, Shepherd and Churchill-Bulletin No. 76, N. Dakota Experiment Station.

<sup>&</sup>lt;sup>†</sup> Maize well manured gives a better fodder containing less fibre and twenty-five to thirty per cent. more proteids than when unmanured. See Snyder,—Minnesota Experiment Station, Bulletin No. 101.

<sup>‡</sup> Kelkar-Bulletin No. 34 (1909), Bombay Agriculture Department, p. 9,

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 com-L pletely.

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.

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 Deccan, 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

<sup>\*</sup> Mollison-Text Book of Agriculture, Vol. III, page 52.

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 themaize stalks in the field<sup>†</sup>.

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,

<sup>†</sup> Alway and Trumbull-Nebraska Agricultural Experiment Station Report, 1909,

<sup>‡</sup> Burtt-Davy-Transvaal Agricultural Journal, Vol. VII (1909).

<sup>§</sup> See Leaflet No. 5 of 1911, Bombay Department of Agriculture,

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 becomes very coarse, and 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 sugar."<sup>†</sup> It will hardly, however, fetch as high a price as sundlia in 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.<sup>‡</sup>

	Percentage digested.			
	Proteids.	Fat.	Nitrogon— 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 riper 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.

<sup>\*</sup> See Poona Farm Report, 1893.

<sup>†</sup> Text Book of Agriculture, Vol. III, page 52.

<sup>‡</sup> Headden-Colorado Bulletin No. 93.

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 Anerica, 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 ipened, and should be fed only to working cattle when mixed with other fodder." The fact that maize fodder so largely bses its value if left till the grain is mature should never be togotten. 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<sup>†</sup>.

But if maize is to be kept, the ideal method of keepingit 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

\* Farm Manual.

<sup>†</sup> See Grisdale-Corn for Ensilage and the Silo, Ottawa, 1912.

small. Sixty-five to seventy per cent. of the weight of green plant used are often obtained as silage five or six months later.

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 be put in the silo without chaffing, but it means a larger from the material becoming mouldy. The better the erial is cut up the better, and some authorities even remend 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 corefully especially near the sides, has given very good results.

r 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.

<sup>\*</sup> 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, At this stage it is best suited for silage."

<sup>†</sup> Lefroy-Indian Insect Pests.

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 h moved, and burnt or otherwise utilized as soon after removal of the crop as possible.

Maize Fly (Delphax psylloides)—This small dark ins not unlike a large aphis, is found in the sheathing leaves o 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 infected 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.\*

Other insect pests have been so far of no practical in portance 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

<sup>\*</sup> Lefory—Indian Insect Pests.

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)	
<u> </u>					p. c.	р. с.	p. c.	 р. с.
Water	•••			••	75·0	75·0	75·0	75·0
Ether Extract (oil, etc.)	••	••			0.2	0.4	0.2	0.6
*Albuminoids (i.e., nitroge	en x 6‡)	••	••		1.2	1.3	t•3	1.2
Digestible carbohydrates	••	••		••	14.0	15.2	14.0	13.1
Woody fibre	••	••	••	••	7.6	6.2	7:3	7.3
Ash	••	•			1.4	1.4	1.9	2.3
					100.0	100.0	100.0	100.0
*Cntaining 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 that of *jowar* already reported (see page 37). Very little alteration in composition and very little change in digestibility occur if the fodder is dried.<sup>‡</sup>

In making silage a considerable loss of digestible carbohydrates, including sugar takes place. I quote analyses

<sup>\*</sup> Annett and Russell-Journal of Agricultural Science, Vol. II (1908).

<sup>†</sup> Ferugho and Mayer, 1909.

<sup>&</sup>lt;sup>‡</sup> See Lindsey-Massachusetts Agricultural Experiment Station Report, 1904. The conclusion is based on experiments on sheep.

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made of silage prepared at the Gokak Farm and in England calculated to a basis of 75 per cent. of water :---

		I Maize silage Gokak Farm.	II Maize silage* Eng- land.
		р. с.	p. c.
Water	••	<b>7</b> 5·0	<b>75</b> .0
Ether Extract (oil, &c)	• • •	0.8	0.2
†Albuminoids (i.e., nit	ro-		
gen x $6\frac{1}{4}$ )	••	2:3	2.8
Digestible carbohydrates	••	11.3	10.4
Woody fibre	••	8.0	9 <sup>.</sup> 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 Constitutents digested.

			Pro- teids.	Fat.	Nitro- gen.	Fibre.
<ol> <li>1) ‡Maize fodder Maize silage</li> <li>(2)§Maize fodder (green) Maize silage</li> </ol>	•••	· · · · · · ·	59.6 46.7 73.5 66.2	72·3 68·3 83·0 82·5	76.1	79·8 67·2 75·3 74 2

\* Annett and Russell -loc cit.

<sup>‡</sup> Bartlett-Maine Agricultural Experiment Station, Bulletin No. 110.

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

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.

# 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

<sup>\*</sup> Neale-Delaware Agricultural Experiment Station Report, 1903.

is looked upon as considerably inferior to the *kadbi* 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.

Bairi 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 vellow during heavy continuous rain. In the Deccan the sowing of *bairi* 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 *sundhia* jowar, but not equal to *nilwa*. In he 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 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 wellfed 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 *nilwa* on the Poona market, and it may be considered as more profitably

<sup>\*</sup> Piper-Forage Plants, page 302.

<sup>†</sup> Garrison-S. Carolina Agricultural Experiment Station, Bulletin No. 123 (1906),

<sup>‡</sup> Connor-Texas Agricultural Experiment Station, Bulletin No. 132 (1911).

<sup>§</sup> Kenny-Rhodesia Agricultural Journal. Vol. VII (1910).

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, &	кс.)		0.4
†Albuminoids (i.e., 1	nitrogen×	6 <del>1</del> )	1.3
Digestible Carbohyd	-	••	20.0
Woody fibre	••		15.8
Ash	••	••	2.5.
		-	
			100.0
+Containing nitroge	n		0.51

#### 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.\*

<sup>\*</sup>Kelkar in Leaflet No. 5 of 1911 of the Department of Agriculture, Bombay.

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 :—

			Yield of dry fod- der.	Length of time growing.	crop.			Number of irri- gations required.	
	1912 and 1913-1	4.		lbs.	days.	Rs.	a. j	р.	
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†				5,600	53	50	0	0	5
April 15†		••	••	4,400	29	51	0	0	5

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

\* Report of the Nadiad Agricultural Station, 1912-13 and 1913-14, † 1913-14 omly, ‡ 1912 only. is a question, however, how far it is of advantage in the cold weather over *shalu 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	••	• 1	60.0
Ether Extract (oil,	, etc.)	••	0.8
*Albuminoids	••	••	2.1
Digestible Carbol	••	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 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.<sup>†</sup> 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 *rala* 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.

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## 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\* :---

"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

<sup>\*</sup> Textbook of Indian Agriculture, Vol. III, page 64,

crop is usually hand-weeded 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  $66^{\circ}$  and  $71^{\circ}$  F. and that below  $64^{\circ}$  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<sup>†</sup>:--

-	Date of sowing.			Yield of dry fodder.	Length of time grow- ing.	Cost of crop.	No. of irriga- tions required.
		<u> </u>		lbs.	Days.	Rs. a. p.	
October 15 November 1 November 15 December 1	  	  	•• •• ••	2,672 2,240 3,440 2,848	53 51 63 75	34 0 0 44 0 0 55 8 0 51. 0 0	3
December 15	••	·· ·	••	3,600	91	48 8 0	3

\* Kelkar 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 growsy much more quickly, requiring sixty-six days as against eightyone 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, makra) 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 tooexpensive 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†

<sup>\*</sup> Meagher and Williams—Farm Manual.

<sup>†</sup> Mollison-Textbook of Indian Agriculture, Vol. III, pages 58 and 60,

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 of green fodder was kept up on the farm, in the hot weather with *jowar*, *choula*,† etc., and *sawan*, and in the cold weater 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

<sup>\*</sup> Meagher and Williams-Farm Manual-

<sup>†</sup> Choula=chavli. See under the latter crop.

berseem should be ready."<sup>†</sup> 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 guite clear. The results in 1913-14 were as follows :--

	Date of sowing. 1913-14.			Yield of Period dry fod- der. ing.		Num- ber of irriga- tions.	
	1913-1	4.		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	65	
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.<sup>‡</sup> 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, etc.,-are

<sup>+</sup> Henderson-Mirpurkhas Farm Report, 1909-10.

<sup>‡</sup> Piper-Forage Plants.

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 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 hav 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 If cut early in the day, the fodder should by the times.

evening be sufficiently dry for 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 hussocks, 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.

<sup>\*</sup> See Leaflet No. 22 of 1909 of the Bombay Agricultural Department. N A 7-12

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 successful<sup>+</sup> and also in the drier regions of Texas.<sup>‡</sup> 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

<sup>\*32</sup> tons of green fodder per acre in four cuttings. Jacobson-Philippine Agricultural Review, Vol. VII (1914).

<sup>†</sup> Scott-Florida Agricultural Experiment Station Report, 1912.

<sup>‡</sup> Hastings-U. S. Bureau of Plant Industry, Circular No 106 (1913).

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.<sup>†</sup> 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.¶

<sup>\*</sup> Surat Agricultural Station Report, 1906-07.

<sup>†</sup> United Provinces Agricultural Department-Bulletin No. 6 (1897).

<sup>‡</sup> Ratnagiri Agricultural Station Report, 1913-14.

<sup>§</sup> Mollison—loc cit.

<sup>¶</sup> Meagher and Williams-Farm Manual.

### 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 per acre should be worked into the soil during the tillage.<sup>†</sup>

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<sup>†</sup>, 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

<sup>\*</sup> We owe practically all the details of cultivation to Mollison. No better methods have been evolved since his time.

<sup>†</sup> Mollison-loc. cit.

<sup>‡</sup> Meagher and Williams-loc. cit.

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.<sup>†</sup>

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 and in 1919-20 46,340 pounds per acre in six cuttings, 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.<sup>‡</sup>

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.

<sup>\*</sup> Leaflet No. 22 of 1909 of the Bombay Agricultural Department.

<sup>†</sup> Florida Agricultural Experiment Station Report, 1911.

<sup>‡</sup> Kelkar-Bulletin No. 34 (1909), Bombay Agricultural Department.

<sup>§</sup> Surat Agricultural Experiment Station Report 1906-07,

Guinea grass is very apt to become overrun 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 eighteen 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.

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.

<sup>\*</sup> Agricultural College Farm Report, Poona, 1913-14.

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 (531 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 Pusat in 1911-12 the maximum yield guoted 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 :---

	Year.	•	Yield per acre.	Cost per acre.	Value of crop per acre.	Number of cuttings.
902			lbs.	Rs.	Rs. 233	10
893 894		••	35,028 21,295	110§ 82	106	10
896 · ·	••	••	19,167	49	96	No record.
897	.••	••	16,106	73§	80	
898	••	••	15,493	53	77	33
899	••	••	13,552	67	68	**
<i>9</i> 00	••		17,103	61	. 114	<b>9</b> ,
90ž			13,662	60	91	
903			12,252	No record.	(Profit Rs. 46)	
904	••		12,551	49	84	4
905			12,559	34	· 89	,,
906	••		15,566	42	78	,,

POONA.

\* Farm Manual.

† Jacobson—Philippine Agricultural Review, Vol. VII (1914). <u>‡ M</u>illigan—Report Imperial Agriculturists 1911-12.

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

These records of yield in Poona tell of the very large vields 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  $5\frac{3}{4}$  tons of green fodder. equivalent to 2<sup>1</sup>/<sub>4</sub> 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.
1898-99 1899-1900	••	 ••		lbs. 28,580 29,549	Rs. 172 116	Rs. 190 197

\* Poona Dairy Farm Report, 1908-09.

· · · · · · · · · · · · · · · ·	Year.	•			Yield per acre.	Cost per acre'i	Value per acre.
and and any set of a	9 9				lbs.	Rs.	Rs.
1900-01 1901-02 1902-03 1903-04 1904-05 1905-06 1906-07	••	··· ·· ··	···. ·· ·· ··	•••	42,594 22,802 29,341 25,835 13,972 18,613 13,484	170 No recor 175 176 167 194 113	213 d 114 147 172 93 124 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.

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<sup>†</sup> 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<sup>‡</sup>, as already stated, where the rainfall is much heavier, it has been so far exceedingly luxuriant though it is

<sup>\*</sup> Report, Dhulia Agricultural Station, 1912-13.

<sup>+</sup> Report, Gokak Agricultural Station, 1912-13 and 1913-14.

<sup>‡</sup> Report Ratnagiri Agricultural Station, 1913-14.

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.

		•	• ;	l Fresh grass (Poona).	2 Fresh grass (Poona).	3 Dried grass (Aver- age).
Water Ether Extract (oil, etc.)   Albuminoids (Proteid ni Soluble Carbohydrates, Fibre Ash	itrogen x 64)	· · · · · · · · ·	· · · · · · ·	p. c. 63 4 0 8 1 9 19 4 8 8 5 7	p. c. 71·5 1·0 2·6 13·7 5·7 5·3	p. c. 10 <sup>.</sup> 0 2 <sup>.</sup> 6 6 <sup>.</sup> 2 45 <sup>.</sup> 8 20 <sup>.</sup> 1 15 <sup>.</sup> 4
			Total	100.00	100.00	100.00
Total nitrogen Proteid nitrogen	••	 	••	0:41 0:30	·53 ·42	1·3 1·0

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

§ Report, Mirpurkhas Agricultural Station, 1913-14.

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

years on the military grass farms and remount deptos. "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,

<sup>\*</sup> Mollison—loc. cit.

t" For young horse stock and dairy cattle it cannot be surpassed " (Mollisan).

<sup>&</sup>lt;sup>‡</sup> Lucas-Journal, Indust. and Engin, Chem., Vol. VI (1914).

and several crops of hay may easily be obtained if the grassis 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—*Eucheaena mexicana* or *Reana 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\* 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)<sup>†</sup> 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.<sup>‡</sup> 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 Arizonall 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 dry fodder per acre. **	Cost per acre.	Value per acrett	
1893 1894 1895 1896	••	· • • • • • • • • • • • • • • • • • • •	· · · · · · · · · · · · · · · · · · ·	Lbs. 9,444 15,204 6,690 2,208	Rs. a. p. 54 0 0 28 0 0 18 0 0 12 0 0	115 0 0 37 0 0

† Dominica Botanical Station Report, 1908-09.

‡ Phillippine 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).

\*\* 24 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 nilva: 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  $5\frac{1}{4}$ 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

<sup>\*</sup>Peona Farm Reports, 1893 to 1896.

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 "milch 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 teosinte 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.<sup>‡</sup>

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.

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

<sup>†</sup> Poona Agricultural College Farm Report, 1913-14.

Crown on diluted sewage at Poona in 1919, sown at the end of May it gave 24,160 lbs. green fodder per acre in three months. At other seasons it was less successful.

in Australia the following figures have been obtained for the green crop completely dried.\*

Ether extract (oil, etc.)		••	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.

#### ANDROPOGON HALEPENSIS.<sup>†</sup>

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

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

<sup>&</sup>lt;sup>†</sup> 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 125). 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.

<sup>&</sup>lt;sup>‡</sup> Piper-Proceedings of the Biological Society, Washington, Vol. XXVIII, p. 25 (1915). N & 7-14

sowing, was realised,—and as the yield in the first year was yev good, it seemed that it was likely to have a future in We 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 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 eradicated.\* 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.<sup>†</sup>

<sup>\*</sup> The question of the eradication of Johnson Grass had 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.

<sup>+</sup> Text Book of Indian Agriculture, Vol. III.

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 rivers, 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 report 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.<sup>†</sup>

<sup>\*</sup> Forage Plants, page 245.

<sup>†</sup> Fodder Grasses of Northern India (1888).

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.

#### 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 veryrich 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 of 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.<sup>†</sup>

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.<sup>‡</sup>

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 resulting from the terrible famine of 1899-1900, one of the most extensive and

<sup>\*</sup> 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).

<sup>&</sup>lt;sup>†</sup> As an example of the kind of climate to which Australian writers refer when speaking of drought resisting conditions, the following averge 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.

<sup>&</sup>lt;sup>‡</sup> Thompson-Annual Report, Guam Agricultural Experiment Station, 1910.

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 reprinted first in "Indian Gardening and Planting" (Calcutta) and the 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,

<sup>\*</sup> Agricultural Ledger (1901) No. 1.

<sup>+</sup> Central Provinces Bulletin No. 7, Agricultural Department (1902).

<sup>‡</sup> Poona Farm Report, 1902 and 1903.

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 soil 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 obtain 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.

## 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

<sup>\*</sup> Nadiad Farm Report, 1903.

lying, and somewhat waterlogged places in the Poona farm. It gave yields as follows :---

	lbs.
1894-95	
1895-96	
1896-97	
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  $13\frac{1}{2}$  tons of green fodder per annum. In spite of this very excellent yield, the grass was allowed to die out, and on its cultivation being recently resumed sets had to be reimported from Ceylon. The new importation has already proved that the grass is worth further trial in Western India under the conditions for which it is suitable. The newly imported material, grown at the Agricultural College Farm, Poona, gave 16,640 lbs. per acre in two cuttings in 1918-19, and no less than 64,000 lbs. per acre in two cuttings in 1919-20.

The best account of its cultivation is that given by Tracy,<sup>+</sup> 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

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

<sup>†</sup> United States, Department of Agriculture, Farmers' Bulletin No. 300.

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 water-logged. 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 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 cutttings, 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

<sup>\*</sup> Hastings—United States Department of Agriculture, Bureau of Plant Industry Circular No. 106 (1913). N A 7—15

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	••	••	<b>7</b> 2 <b>·</b> 9	
Ether Extract (oi	, etc.)	••	0.5	
Proteids (Nitroge	$n \times 6\frac{1}{4}$ )	••	1.4	
Digestible Carbo	hydrates		13.8	
Woody fibre	••	• •	9.6	
Ash	• •	• •	2.1	
		- 10	00.00	

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 moderately 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.

<sup>\*</sup> Hastings-United States Department of Agriculture, Bureau of Plant Industry Circular No. 106 (1913).

<sup>•†</sup> Watts-West Indian Bulletin, Vol. III (1903).

<sup>‡</sup> Guam Agricultural Experiment Station Report, 1914,

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 semiwaterlogged 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.

## 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.

\* 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. R. 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 —

3rd glume	Rhodes grass (Chloris gayana) Sparingly hairy, awn short	Ve
5th glume	Very shortly awned	Re
6th glume	Reduced to a clavate body	N
Spikes	Long	Sh
Habit	Robust and erect	W

Chloris virgata. Very hairy, awn long. Reduced to a clavate body. Non-existent. Short. Weak and spreading.

<sup>†</sup> My account of Indian experience with this grass is almost entirely derived from notes published by Home and Draper on the experiments at Bangalore (Army Headquarters India, November 1915). 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 *hariali* (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 benefitted by adding a dressing (two inches thick) of coarse sand.

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 *jhabau* 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 was 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.	Poona.	Ahmedna- gar.	Belgaum.	Ahmeda- bad.
January February March April May June July August September Octoper	··· ·· ·· ·· ··	· · · · · · · · · · · · · · · · · · ·	ins. 0·2 0·1 0·6 1·3 5·0 3·2 4·0 5·9 6·3 6·4 1·9	ins. 0·1 0·1 1·4 5·2 7·6 3·7 5·0 4·3 0·9	ins. 0·1 0·1 0·3 0·8 4·6 3·2 3·0 7·0 2·9 0·8	ins. 0·1 1·7 2·6 8·4 15·7 8·9 4·8 5·0	ins.  0°1  0°3 3°8 12°5 7°6 4°3 0°4
November December	••	•••	1.7	0.3	0.6	1·4 0·3	0·4
	Total	•••	35.6	29.3	23.5	49.3	29.1

Bangalore and in three or four centres of Western India is as follows :---

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. The experience at the Dharwar experimental station confirms this doubt. for there on land which was selected because it retains much moisture in the cold weather, the grass never grew well except in the rains. In the rabi season only a very small cutting was obtained in December and January.\* 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 most 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.

<sup>\*</sup> Dharwar Agricultural Station Report, 1918-19.

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."\*

animals<sup>†</sup> and in Australia, it is looked upon as more nutritious than *Paspalum dilatatum* being richer in proteids and poorer in fibre. Its composition varies very much at different stages<sup>‡</sup> and at a stage when suitable for cutting is shown in the following anlyses, the grass being air dried before anlysis. The first two are samples from Hawaii,§ the third is a sample from Bangalore done in my laboratory.

				Hav Samj		Ban- galore Sample.
Water Ether Extract ( Proteids Digestible Car Woody fibre Ash	 bohydrate:	 •••	••• •• •• ••	p. c. 11.7 2.3 6.1 42.5 30.2 7.2 100.00	p. c. 9.8 1.4 7.3 44.7 29.2 7.6	

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.

<sup>\*</sup> Home and Draper-loc cit.

<sup>+</sup> Agricultural News of West Indies, Vol. XIII (1914).

<sup>‡</sup> See Agricultural Gazette, New South Wales, Vol. XXI (1910).

<sup>§</sup> Thompson-Hawaii Agricultural Experiment Station Report (1903).

<sup>¶</sup> Hungerford-Phillippine Agricultural Review, Vol. V (1912).

## 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 possibily 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.

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  $4\frac{1}{2}$  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

<sup>\*</sup> Agricultural Horti-Society of India. Poceedings, 1888. Quoted by Davy, Kew Bulletin, 1913.

<sup>†</sup> Gollan-Saharanpur Garden Report, 1888.

<sup>‡</sup> Davy-Kew Bulletin, 1913.

Prain in July 1915 stated that he considered it possibly suitable for areas in the South Western Punjab, Rajputana, Central India, Hyderabad and Mysore. As the climate of much 'of Western India does not differ wiedly 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 few 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 has 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. 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

<sup>\*</sup> Cawnpore Agricultural Station Report, 1914 and 1915.

(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 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 anlysis :--\*

	 	South a	Africa.	Cawn-
· .		(1)	(2)	pore.
Moisture Ether Extract (oil, etc.)	 	Per cent. 8'88 1'21	Per cent. 9°16 1°07	Per cent. 6'95 2'01

<sup>\*</sup> Ingle-Transvaal Department of Agriculture, Annual Report 1906-07 and Cawnpore Agricultural Station Report, 1914.

			South A		
			(1)	(2)	Cawnpore.
Proteids Digestible Carbohydrates Woody fibre Ash	· · · · · · · · · · · · · · · · · · ·	•••	Per cent. 6°21 39°08 39°07 5°35	Per cent. 4·72 42·71 35·63 6·71	Per cent. 4.06 51.43 29.35 6.20
			100.00	100.00	100.00

#### STATEMENT-continued.

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 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.large-

<sup>\*</sup> 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 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.

ly 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<sup>†</sup> 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.<sup>‡</sup>

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

<sup>\*</sup> U.. A. Farmers' Bulletin No. 605.

<sup>†</sup> In this description I quote largely from Piper-Forage Plants.

<sup>&</sup>lt;sup>‡</sup> Phillippine Agricultural Review, Vol. IV 1911), page 394.

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

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 only recently been made in India with it, seems to possess decided possibilities as a fodder crop, namely Elephant grass or Napier's Fodder (*Pennisetum purpurem*), which has recently leapt into prominence in Rhodesia, South Africa, as a drought resisting grass.<sup>†</sup> 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 twothirds 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

<sup>\*</sup> This difficulty of distinguishing the seed is probably the source of the confusion in these grasses to which I have previously referred.

<sup>+</sup> Rhodesia Agricultural Journal, Vol. X (1913), Nos. 3 and 6.

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  $\wedge$ 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 24 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. In Poona, at the Agricultural College farm under irrigation, it gave in 1918-19, 28,000 lbs. per acre in three cuttings, and in 1919-20 the very good return of 43.840 lbs. per acre in four cuttings. Under sewage effluent, near Poona, it has given much larger yields as large as 81,240 lbs. per acre in five cuttings and was its best in the hot weather and monsoon.

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,	etc.)	0.29
Proteids (nitrogen	× 6°25)	2.92
Digestible carbohy	drates	17.29
Woody fibre	••	14.77
Ash	• •	2.92
		·
		100.00

<sup>\*</sup> 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.

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 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 It is highly relished by cattle, who will sort it out grasses. 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

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<sup>\*</sup> Agricultural Journal of India, Vol. X (1915), page 290. The account given is taken in all essentials from his description

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.

This grass has not however proved a success in somewhat retentive soil at Dharwar where it was cultivated for three years. In the third year the yield of green grass was only 3,481 lbs. per acre, and it really only grew in the monsoon. But here it was planted on somewhat hard land, which cracked during the cold weather. This may account for the small return obtained.\*

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 follwoing results :---

		Before flower- ing.	In flower.	In seed.
Moisture Ether extract (oil, etc.) Proteids (nitrogen x 6 <sup>.</sup> 25) Digestible carbohydrates Woody fibre Ash	    · · · · · · ·	Per cent. 69·9 1·6 2·1 13·5 9·2 3·7 100·0	1.7 2.2 14.9 11.6 3.7	65.4 1.7 2.0 12.8 14.3 3.8

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

\* Dharwar Agricultural Station Report, 1918-19,

## 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 locerne. Small patches of lucerne are now found in cultivator's fields in many, if not in most, of the well-irrigated villages in the Deccan and Gujarat. It was planted very largely during the famine of 1918-19.

<sup>\*</sup> De Candolle.

<sup>&</sup>lt;sup>†</sup> Mollison-Text Book of Indian Agriculture, Vol. III, page 229, and see also Thompstone, Agricultural Journal of India, Vol. IV, page 319.

## Climate Required for Lucerne.

Lucerne is the typical leguminous fodder crop for semiarid 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 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, etc.,—there need be no anxiety on account of liability to damage by frost.<sup>†</sup> Certain varieties are so cold resistant that they are grown in the northern parts of Siberia (Yakutsk).

<sup>\*</sup> Report, Mirpurkhas Agricultural Station, 1913-14.

<sup>†</sup> Very interesting experiments on the cold resistance of different kinds of lucerne are detailed by Brand and Waldron in the United States Department of Agriculture, Bulletin No. 185, Bureau of Plant Industry.

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, has hitherto prevented 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 perhaps, 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 vield 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 the meantime an increasing amount of lucerne is actually now planted annually in the more favourably situated parts of the Konkan.

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 nearly 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 been so used. I will give two or three examples of failure and also one of moderate success.

1906-07 Turkestan lucerne was imported from In 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 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.<sup>4</sup> the same four strains as were tried at Dharwar 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,<sup>‡</sup> where lucerne is regularly grown, in 1909-10, grew very well, at first giving a fair return in the

<sup>\*</sup> Report, Dharwar Agricultural Station, 1906-07.

<sup>†</sup> Report, Dhulia Agricultural Station, 1906-07.

<sup>‡</sup> Report, Manjri Agricultural Station, 1909-10 and 1910-11.

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.

A somewhat successful attempt to grow our local lucerne as a dry crop at Dharwar may be recorded. It was sown in 1916 on well-drained retentive soil, and maintained itself for three years. The absence of irrigation caused it to grow stunted and to flower at very short intervals. It gave yields as follows :-First year 9,420 lbs. per acre : second year 17,925 lbs. per acre : third year 9,120, lbs. per acre. Of course these yields are small compared with what can be obtained under irrigation, but they show what can be done, at least at Dharwar, by careful cultivation, even without the application of water.<sup>‡</sup>

There are said to be three varieties usually grown in India<sup>‡</sup>—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 much to be 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,

<sup>\*</sup> Report, Agricultural College, Agricultural Station, 1909-10.

<sup>†</sup> Dharwar Agricultural Station Report 1918-19.

<sup>‡</sup> United Provinces Agricultural Department, Bulletin No. 6 (1911).

<sup>§</sup> Mollison-Text Book of Indian Agriculture, Vol. III, page 230.

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 herehas hairy, large leaflets, grows very rapidly, and is said to die earlier than most other varieties. It produces more cuttings per season than to 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 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

<sup>\*</sup> Mollison—Text Book of Indian Agriculture, Vo. 111, page 230.

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 the best, 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 dving. 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.<sup>‡</sup> 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 It practically never occurs, however, in Western India. land.

<sup>\*</sup> Coburn-The Book of Alfalfa, page 44.

<sup>†</sup> Traphagen-Montana Agricultural Experiment Station, Bulletin No. 54.

<sup>‡</sup> Hilgard-Soils, pp. 467 and 472.

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## 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.

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.<sup>†</sup>

	Date of sowing.					Yield of green Lu- cerne.	
August September October November December	1913.     1914.	   	· · · · · · ·	19 19 16 15 13	6 6 5 5 4	lbs. 15,600 21,480 18,000 18,840 11,360	-
January February March April	••• •• ••	  	•••		4 2 ailed. ailed.	13,680 1,280	

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

<sup>\*</sup> Poona Experimental Farm Report, 1893.

<sup>†</sup> Nadiad Agricultural Station Report, 1913-14.

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 Caltivation.

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 than when once established its should last.\*

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, and every six to eight days in the hot season according to the character of the soil."\* The present method of cultivation of lucerne in Sangamner, 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 :--

"Lucrene is sown at the end of October or in the begin" ning of November. The land is not left fallow in the monsoon. Some crop, generally *bajri*, which requires 3 to  $3\frac{1}{2}$ 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. bairi is sown. No mixture whatever is sown in the bairi, 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. Bairi 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 bairi 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,

<sup>\*</sup> Poona Agricultural College Magazine, Vol. VI (1915), page 177.

manure instead of earth, at the rate of fifteen to twenty cart loads 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 poudrette instead of farmyard manure, and these say that the lucerne from the fields manured with poudrette 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, 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 thorughly 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\* :--

		Yield.		
		Planted on ridges.	Planted in beds.	
		Pounds per acre	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	

\* Agricultural College Station Report, 1913-14.

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

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."<sup>†</sup> In this case the difference was much greater than in other places : the yields in the first and second years were as follows :—<sup>‡</sup>

		Yield per acre.	
		lst year. Ibs.	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.

<sup>\*</sup> Manjri Agricultural Station Report, 1910-11.

<sup>†</sup> Surat Agricultural Station Report, 1907-08.

<sup>&</sup>lt;sup>‡</sup> Surat Agricultural Station Report, 1905-06 and 1906-07.

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 of 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 about Rs. 50 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 eighten inches, it may be used in practically all cases, and it leaves the furrow clean so that the water can flow properly. This should be done immediately after cutting of the crop has been taken, and as frequently as the growth of the weeds demands.

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 per acre 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 recognized 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 1893.*
I. Farmyard manure	Rs. a. p. lbs. 133 0 0 26,860
(15 tons before planting) (7 tons after every second cutting) II. Castor cake	143 0 0 29.824
<ul> <li>(7½ cwt. before planting)</li> <li>(3 cwt. after every second cutting)</li> </ul>	143 0 0 29,824
<ul> <li>III. Crushed Bones (10 cwt. before planting) (4 cwt. after every second cutting)</li> </ul>	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.

<sup>\*</sup> In nine cuttings. See Poona Experiment Farm Report, 1893. N & 7--19

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 nowadays), 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.

Additional manures per acre.		Cos addit man	ion	al	Average yield.	Increased yield over plot I.			· •
	-;	Rs.	а.	p.	lbs.	lbs.	Rs.	a.	<u>р</u> ,
I. Nil	•	٨	lil.		18,711	Nil.	٨	lil.	
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	29,578	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

<sup>\*</sup> Knight and Patil—Agricultural College Farm Reports, 1912-13, 1913-14, 1914-15. Also summarized by Mann and Paranjype in Bombay Agricultural Department Bulletin No, 79 (1915).

(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, Jabout Rs. 12 per acre.

Lucerne has been very successfully grown, on the ridge and furrow system, when watered by sewage septic tank affluent. 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 follows, in twelve cuttings :--

	Yield July 19th 1899 to May 2nd, 1900.		ost.		Valu cro	-	E
	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.
<ol> <li>Farmyard manure 10 tons</li> <li>Poudrette 10 tons</li> <li>Sewage effluent 21 waterings</li> </ol>	••	lbs. 44,100 56,530 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, nowadavs. 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, the sewage 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

<sup>\*</sup> In 1918-19 an experiment near Poona with septic tank effluent mixed with twice its amount of water applied every ten days gave 26,413 pounds per acre in 12 cuttings within 12 months of sowing.

annum, each cutting weighing from 4,000 to 6,000 pounds of green fodder. This gives a total yield per annum of from 1,20,000 pounds to 1,80,000 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 utilize 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 conjuction 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.

† Shutt-Canada Experiment Farms Report, 1909.

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

<sup>‡</sup> Waldron-N. Dakota Agricultural Experiment Station Report (sub-station), 1908.

<sup>§</sup> Wright-West of Scotland Agricultural College Report, Vol. X (1911).

<sup>||</sup> Donnan-Agricultural Gazette, New South Wales, Vol. XXIII (1913), page 953.

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 prepared 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.

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

<sup>\*</sup>Saunders, etc.-Canada Experiment Farms Reports, 1910.

<sup>†</sup> Pugsley—Nebraska Agricultural Station Bulletin No. 136 (1912). § Mirza—Loc. cit.

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.

Verv 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-24,389 pounds per acre.

Plot irrigated every thirty days-18,289 pounds per aere.

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.

<sup>\*</sup> Report, Surat Agricultural Station, 1906-07.

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 Yover much of our area—35.66 inches were given or water equivalent to nearly 41 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 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 271 to 28 inches of rainfall, and in Montana with only 81 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 no 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

<sup>\*</sup> See Fortier-U. S. Farmers' Bulletin, No. 373 (1909).

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 equi 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.

Immediately on being cut, growth begins again, and cops 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 braches

<sup>\*</sup> These tests are given by Fortier, loc. cit.

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 claster.\*" 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.	(20 ton) and canal water. Pounds of green	Poudrete (20 ton) 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	••	••	••		••	12,992	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

\* Thompstone-Agricultural Journal of India, Vol. IV, page 321.

+ Poona Experiment Farm Report, 1900-01.

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.

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.

lst c	utting		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 sugarcane heavily manured. The average return lies, however, between 30,000 and 40,000

<sup>\*</sup> Dairy Farm Report, Poona, 1905-06.

<sup>†</sup> Text Book of Indian Agriculture, Vol. III, page 233.

pounds per acre of green fodder. Actual returns on plots manured in a normal fashion at Poona or Manjri are as follows :--

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 lucerne previously referred to (page 147) the relative amounts in the first and second year were as follows :---

	Green fodder per acre.			
	lst year	2nd year		
Sewage septic effl-				
uent	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 :---

First	year	(1892-93)	83,793	lbs. green	fodder
				per acre.	
Second	l 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 Manirit with various kinds of manure, an average over all plots gave-

> First year ... 23,550 lbs. green fodder per acre. Second year. 21.151 ,, ,,

This shows a loss of about 10 per cent. in the second year's crop, and even this is more than in 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 leaest equal returns to the first, and this is probably obtainable generally if the cultivation is good, if the soil is fairly free from weeds, and if the manuring at first has not been excessive.

<sup>\*</sup> Loc. cit.

<sup>†</sup> Manjri Agricultural Station Report, 1904-05.

<sup>&</sup>lt;sup>‡</sup> October to March only. Agricultural College Farm Report, 1913-14,

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 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 a fungus disease (of which more later) Mollison suggested that any gaps in the lucerne should be filled with sets of 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 a part, 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. 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>†</sup>

<sup>\*</sup> Surat Agricultural Station Report, 1907-08.

<sup>†</sup> See Poona Farm Reports, 1893-94, 1894-95, 1896-97 and 1897-98.

In spite of these increased yields, the method never became popular, and with the disappearance of the fungus disease mentioned, as a serious menace, 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 7,904 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 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 had been suggested that wherever irrigation facilities area 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.‡

<sup>\*</sup> Dohad Agricultural Station Report, 1913-14.

<sup>†</sup> Report, Ratnagiri Agricultural Station, 1913-14.

<sup>‡</sup> Private communication from Mr. K. V. Joshi, B.Ag.

The crop should be sown immediately after the harvesting of the *kharif* ricer 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 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.<sup>†</sup>

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 lavala (Cyperus rotundus). It is those weeds that seem to make long continued cultivation of lucerne on one site impossible, and unless absolutely therough 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,

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<sup>\*</sup>Bombay Agricultural Leaflet No. 11 of 1915. †Report, Poona Agricultural Station, 1894-95.

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 *nimoli* 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 guickly 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 dodder infested lucerne 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)

<sup>\*</sup>See Patwardhan-Agricultural Journal Ind., Vol. IV, page 357.

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.

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.<sup>†</sup> 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

<sup>\*</sup> Poona Agricultural College Magazine, Vol. VI, page 180.

<sup>+</sup> Bombay Agricultural Leaflet No. 12 of 1915.

<sup>‡</sup> Poona Agricultural Experiment Farm Report, 1896-97.

with strychnine 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 :---

Wages of two coolies at 5 annas	S	Rs. 0	10	0	
Cost of $1\frac{7}{8}$ lbs. of sulphur . Cost of charcoal .	•	0 0	3 1		
	-	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*<sup>†</sup> 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,

<sup>\*</sup> Poona Agricultural College Magazine, Vol. VII (1915), page 79.

 $<sup>\</sup>dagger$  One guntha = one fortieth of an acre,

and a flexible wire tube and pump for discharging the fumes into the holes. As imported it cost about Rs. 70 before the war 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 as attacking lucerne, there are only two serious insect pests in Western India, the lucerne aphis and the lucerne caterpiller (*Laphygma exigua*). The former of these is exceedingly serious and may materially affect the success of the cultivation. I am much indebted to Mr. R. 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 *Chaitophorus* 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

<sup>\*</sup> Indian Museum Notes, Vol. IV (1900), page 377.

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 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 aphis 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 aphis climb on to the young tender shoots which spring up very quickly after every cutting, and kill these off. plants in consequence get weaker and weaker at each cutting.

<sup>\*</sup> Private communication to the author.

"If the aphis 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 (aphis) 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 aphis 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 aphis, 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 aphis, 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.

<sup>\*</sup> Poona Agricultural College Magazine, Vol. VI, Page 180.

(4) If there be heavy rains, the aphides 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 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

<sup>\*</sup> Private communication from R. S. Kasargode.

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, etc."

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<sup>+</sup> 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

<sup>\*</sup> See Reports, Poona Experiment Farm, 1893-94 and 1894-95, particularly.

<sup>&</sup>lt;sup>+</sup> Scientific Memoirs by Medical Officers of the Army in India, Part X (1897), p. 124. M A 7-22

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 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 were 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 violacea*, 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, (though I had serious trouble with it at Poona in 1918), 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.<sup>†</sup>

<sup>\*</sup> Mem. Agric. Dept. Ind. Botanical Series, Vol. VII, No. 4 (1915).

<sup>†</sup> Surat Agricultural Station Report, 1912-13.

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 Airekar (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 really 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<sup>\*</sup> is the spot disease of the leaf (*Pseudopeziza medicaginis*), 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 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.<sup>†</sup>

<sup>\*</sup> See Thompstone-Agricultural Journal Ind., Vol. IV, page 334 (1909).

<sup>†</sup> New Jersey Experiment Station-quoted by Piper-Forage Plants, page 357.

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 was usually worth at least Re. 1 per pound up to 1917. Since that time, however, it has usually be and saleable at new Rs. 2 per pound, and occasionally has gone as high as Rs. 4 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

<sup>\*</sup> Osborne-Journal of Agriculture, South Australia, Vol. XVII (1913), page 294.

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<sup>\*</sup> 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 greastest amount of good fodder, do the least injury to the plant, and 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 aphis or other insects, so we have only to consider the best stage for cutting.

It is unfortunate that we cannot show, by analyses 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.

<sup>\*</sup> United Provinces, Bulletin No. 6 (2nd edition), 1911.

		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.<sup>†</sup> 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.<sup>‡</sup>"

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 decrease 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

<sup>\*</sup> Kansas Agricultural Experiment Station, Bulletin No. 155 (1908).

<sup>†</sup> See Soderbaum-K. Land. Akad. Handl. Tidski, Vol. XL. (1901), page 364.
‡ Widtsoe.

<sup>§</sup> Foster and Merrill-Bulletin No. 61, Utah Agricultural Experiment Station,

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 in cattle or sheep, though not in horses. The danger is, however, very remote with cut lucerne, especially if it is allowed to stand and wither slightly 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 normally 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 shatterred 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 (Thompstone).

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 ofspoiling.

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.

<sup>\*</sup> Ganeshkhind Gardens Report, 1909-10.

# 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 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 1904,

<sup>\*</sup> U. S. Department of Agriculture, Bureau of Plant Industry, Bulletin No. 23 (903), N A 7–23

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, vielded 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  $7\frac{1}{2}$  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.<sup>+</sup> 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 exteneded 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 lucerne 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 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. The

<sup>\*</sup> Report, Mirpurkhas Agricultural Station, 1904-05 and 1905-06.

<sup>+</sup> Henderson-Mirpurkhas Agricultural Station Reports, 1905-06, 1906-07 and 1908-09.

<sup>‡</sup> Henderson-Mirpurkhas Agricultural Station Report, 1910-11.

war has checked development in this as in so many other directions, but berseem, as a fodder crop, has come to stay in Sind.

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.<sup>†</sup> 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<sup>‡</sup> 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

<sup>\*</sup> See Marriott-Agricultural Journal Ind., Vol. X (1915), page 81.

<sup>†</sup> Poona Experimental Farm Report, 1894-95.

<sup>‡</sup> Agricultural College Agricultural Station Report, 1913-14.

<sup>§</sup> Nadiad Agricultural Station Report, 1912-13.

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 34,451 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 soil, (2) that it is particularly g ood for opening up the soil, (3) that it "possesses high manurial value for the crops which follow it," (4) that 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

<sup>\*</sup> Dohad Agricultural Station Report, 1913-14.

<sup>+</sup> Alibag Agricultural Station Report, 1913-14.

<sup>&</sup>lt;sup>‡</sup> Foaden and Fletcher-Text-Book of Eyptian Agriculture, Vol. II, page 462.

<sup>§</sup> Agricultural Journal of India, Vol. X (1915), page 81.

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 :---

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1	А.	В.
	p. c.	p. c,
••i	·099	· 101
	·110	.116
	·113	•111
	·105	•• ,
	·099	. ••
		p. c. 099 110 113 105 

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 :---+

# 1. Two years' Rotation.

	lst year.	2nd year.
Rabi crop	Berseem ploughed in	Berseem allowed to seed.
Kharif crop	Cotton.	Bajri or Jowar.

\* United States Department, Bureau of Plant Ind., Bulletin No. 62. † Mirpurkhas Agricultural Station Report, 1910-11.

	lst year.	lst year. 2nd year.	
Rabi crop	Berseem ploughed in	Berseem allowed to seed	Wheat.
Kharif crop	. Cotton.	Fodder Jowar.	Bajri or Jowar.

11.—Three years' Rotation.

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.
lst ci	utting	••	4,978
<b>2nd</b> -	**	••	8,032
3rd	**	• •	12,784
4th	,,	••	13,940
5th	**	••	10,912
6th	33	• •	2,870

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. In 1916, 68,962 pounds per acre of green berseem were obtained at Sukkur. 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 Mirpurkhast 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

<sup>\*</sup> Sukkur Agricultural Station Report, 1911-12. A good account of berseem cultivation in Sind is given in Bulletin No. 91, Bombay Department of Agriculture (1919).

<sup>†</sup> Report, 1912-13 and 1911-12.

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., proteids-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 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.<sup>†</sup>

# Berseem Seed.

Berseem seed as imported from Egypt is usually very dirty, and a good average sample contains about seven per

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<sup>\*</sup> See Means-United States Department of Agriculture, Year book, 1902.

<sup>†</sup> Daulatpur Reclamation Station Reports.

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.<sup>†</sup>

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.<sup>‡</sup> 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, and a good deal of difficulty has been found in growing good quality seed in Sind.

# 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 littoralis). 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.

<sup>\*</sup> Foaden and Fletcher-Text Book of Egyptian Agriculture, Vol. II, page 469.

<sup>†</sup> See Agricultural Journal, Ind., Vol. VIII (1913), page 306, and Vol. X (1915), page 85 (foot note).

<sup>\$</sup> Brown-Agricultural Journal Ind., Vol. X (1915), page 402.

<sup>§</sup> See Bonaparte-Journal Khed, Agric. Soc., Vol. IV (1902), page 224.

## 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 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 he has 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

<sup>\*</sup> Fruit Experiment Station, Quetta, Bulletin No. 5 (1915). Most of the data which follow are from his bulletin.

In the plains it has proved of little use. vallevs. 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 vield four crops in one year, three of which can be utilised for fodder and the last either for seed or as greenmanure. 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.

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 unmanured 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, mules, 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 drving. 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 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 eharacter, 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 cne 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

<sup>\*</sup> Meagher and Williams-Farm Manual, page 62,

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<sup>‡</sup>. 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.<sup>‡</sup>

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. And yet the great success with this crop, in places like Kansas with a climate not unlike ours, would well justify further experiment with it.§

## 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

<sup>\*</sup> Report, Mirpurkhas Agricultural Station, 1905-06.

<sup>†</sup> Agricultural College Station, Poona, Report, 1909-10.

<sup>‡</sup> Report, Dharwar Agricultural Station, 1909-10.

<sup>§</sup> See Kansas Agri. Expt. Station Bulletin 225 (1921).

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 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 the 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

<sup>\*</sup> Mollison-Text Book of Agriculture, Vol. III, page 89.

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.<sup>\*</sup> 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.
1894 1895 1905	••	Lbs. 40 48 No re- cord.	Lbs. 12,089 7,346 6,981	17 0 0 13 8 0	

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.
1910 1901 1912	16.000	Second cutting very poor No second cutting. Two cuttings.

\* 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<sup>†</sup> 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

<sup>\*</sup> See Reports, Larkhana and Landhi Agricultural Stations, 1913-14.

<sup>†</sup> Report, Kirkee Dairy Farm, 1904-05.

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 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 hav.\*

Yield.—I have already indicated (page 193) the quantity of crop which has been obtained in our experiments at differrent 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

<sup>\*</sup> Doane-Maryland Agricultural Experiment Station, Bulletin No. 98 (1905).

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 ob-

tained 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 bairi 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, etc.) 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 aphis (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 (Am-

sacta 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 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 recognizing 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<sup>†</sup> renders the possibility of such an attack here not very remote

<sup>\*</sup> I am indebted for the substance of the account of this pest to Mr. R. S. Kasargode of the Poona Agricultural College.

<sup>+</sup> Butler-Report, Agricultural Resear h Institute Pusa, 1911-12.

If such an attack does occur, the crops had better be cut down, the fand 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 follows\* :—

·			full	Cut when pods forming.	Cut when pods formed.
Ether extract (fat, &c.) Proteids Digestible Carbohydrates, Fibre Ash	 &c.	· · · · · · ·	Per cent. 4·04 17·86 52·28 18·29 7·43	19·93 50·58	5·01 21·38 32·59

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 constituents of the fodder have been given by American authorities with cattle :---

Dry matter	68	per	cent.	digestible.
Fat	59	,,	,,	,,
Proteids	<b>7</b> 6	,,	,,	**
Digestible carbohy-	•			
drates	81	,,	,,	,,
Fibre	<b>6</b> 0	,,	••	,,

There is practically no waste in feeding *chavli* fodder. Even when it is a little mouldy it is eaten freely by stock of

\* See Piper-Forage Plants, page 502.

† See Voorhees-Forage Crops, page 66.

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 in *val* (*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 1895 per acre.
Chavli Vul	 Lbs. 12,089 7,998	<sup>•</sup> Lbs. 7,346 7,528

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.
1910 1911 1912	· ·	Lbs. 12,000 22,000 16,533	First cutting only. Gave a good second cutting. In three cuttings. 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 mediun 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.

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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 alwavs 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 recognized, 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, Ansacta 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 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* biflorus) 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

<sup>\*</sup> Poona Experiment Farm Report, 1896-97.

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 fodder with *bajri* or *jowar*. It was recognised as a better fodder even than *val* or *chavli*.‡

In Sind its cultivation was taken up as a *kharif* 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 seem to be no use in Sind. Under all conditions of growth where successful it has only given one cutting.

<sup>\*</sup> Bombay Agricultural Department, Bulletin No. 15 (1892).

<sup>†</sup> Poona Experiment Farm Report, 1895-96.

<sup>‡</sup> Report, Poona Experiment Farm, 1897-98.

<sup>§</sup> Report, Mirpurkhas Agricultural Station, 1910-11.

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 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 twenty-five 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. Mukeriit 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.<sup>‡</sup>

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* 

<sup>\*</sup> Text Book of Agriculture, Vol. III, page 83.

<sup>+</sup> Handbook of Indian Agriculture (3rd edition), page 203.

<sup>‡</sup> Saidapet Farm Reports.

(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, etc.).	0.6	,,
Proteids	3.4	,,
Digestible carbohydrates	12.9	,,
Woody fibre	<b>7</b> •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 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 trifoliate and angularly toothed. The small flowers are

<sup>\*</sup> Piper-Forage Plants, page 557.

numerous in short, erect axillary racemes. The pods are flat, 13 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 were 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.<sup>†</sup>

At Landhi, near Karachi, it has given a very heavy yield of fodder.<sup>‡</sup>

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

<sup>\*</sup> Piper-Forage Plants, page 557.

<sup>†</sup> Reports, Mirpurkhas Agricultural Station, 1910-11, 1911-12, 1912-13.

<sup>‡</sup> Report, Landhi Agriculture Station, 1913-14.

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 that 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.

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.<sup>†</sup> 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	••	<b>77</b> .0	73.8
Ether extract (fat, &c.)	••	0.2	0.8
Proteids	••	4.6	4.3
Digestible carbohydrates	••	10.2	8.9
Fibre		4.0	7.9
Ash	••	3.2	4.3
	-	100.0	100.0

\* Mukerji-Handbook of Agriculture (3rd edition), page 205.

+ Duthie and Fuller-Field and Garden Crops.

# 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 soybean 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

\* Poona Experiment Farm Report, 1905-06,

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well, gave a large quantity of leaf, and came to maturity in three months, giving 400 pounds of grain and 2,240 pounds of stalks per acre. The American varieties (Haberlandt, Hollybrook 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.\*

<sup>\*</sup>Private communication from Mr. G. H. Frost to the author.

As to manner of cultivation, soybeans closely 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  $2\frac{1}{2}$  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 futher 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.

<sup>\*</sup> Most of these details are obtained from Piper, Forage Crops, pages 513 to 530,

As a fodder, the crop is richer in proteids than most other leguminous crops, but it is more woody and fibrous thanchavli, 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 :---{

			Composi- tion.	Percentage of digesti- bility.
Moisture Ether extract (fat, &c.) Proteids Digestible carbohydrates Fibre Ash	•••	    · · · · · · · · ·	    p. c. 75.1 1.0 4.0 10.6 6.7 2.6	р. с. 55 78 77 45

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.<sup>†</sup> At the same time it is generally recognised throughout Western and Northern India that the plant furnishes very valuable fodder,<sup>‡</sup> 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

<sup>\*</sup> Voorhees-Forage Plants, pages 266 and 366. † Poona Experiment Farm Report, 1893.

<sup>‡</sup> See Watt-Commercial Products of India, under Pisun,

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 be well manured with cattle and other farmvard 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

<sup>\*</sup> Poona Agricultural College Station Report, 1912-13.

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  $2\frac{1}{2}$  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 Maniri 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 fed 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	•••	<b>79</b> .4
Fat (Ether extract)	••	0.2
Proteids	••	2.1
Digestible carbohydrates, etc.	••	10.0
Fibre	••	6.5
Ash	••	1.6
	-	
	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.<sup>†</sup> 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 foenumgraecum*) 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

<sup>\*</sup> Voorhees-Forage Crops, page 187.

<sup>†</sup> Poona College Agricultural Station Report, 1912-13.

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.<sup>†</sup> 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 onefifth 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

<sup>\*</sup> Foaden and Fletcher-Text-Book of Egyptian Agriculture, page 561 (1910).

<sup>† 1</sup> am indebted for most of what follows to an article by Athalye, Poona Agricultural College Magazine, Vol. VII (1916), page 226.

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 aphis, and checks the tillering 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 twenty-five 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

<sup>\*</sup> See Klemmer and Kruger-Centralblatt fur Bakt. (11), Vol. XL (1914), page 256.

<sup>†</sup> Reddish or yellowish green seed is considered inferior. The usual price of methi seed is 8 to 12 pounds per rupee.

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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 fenugreek 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 aphis, 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 broadcasted, 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 Sann-hemp (*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

<sup>‡</sup> Staubenrauch-California Agricultural Experiment Station Report, 1904.

of being grown well on into the hot weather. It is not expensive to grow, the chief charges being for irrigation, 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 there 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 those 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

<sup>\*</sup> Poona Experiment Farm Report, 1897-98.

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.

Definite experiments have, I think, only been carried out at Mirpurkhas (Sind) with this pulse as a fodder. It was there tried in the *kharif* 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.

<sup>\*</sup> Report, Mirpurkhas Agricultural Station, 1910-11, 1911-12, 1912-13.

† Dohad Agricultural Station Report, 1910-11.

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.<sup>†</sup> 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

<sup>\*</sup> Poona Experiment Farm Report, 1903-04.

<sup>†</sup> Kirkee Dairy Farm Report, 1904-05,

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 kharif fodder. The experiments on it have only just commenced, however, but at 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

<sup>\*</sup> Kirkee Dairy Farm Report, 1905-06.

<sup>†</sup> Landhi Agricultural Station Report, 1913-14.

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