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The Development of the Indian Sugar Industry.

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I. History of the Production of Sugar.

DISTRIBUTION OF SUGAR IN NATURE :—Sugar occurs in nature in many plants, the principal of which are cane, beet, sorghum cane, sugar maple, maize and sugar palms. Cane was the first plant in which sugar was discovered. The discovery of sugar in beet dates from 1747 and is due to a German Chemist, Marggraf. Maple sugar has a delicious flavor and is a commercial commodity in the eastern parts of the United States and Canada. However, its production does not play any figure in the sugar markets of the world. Sugar is produced in considerable quantities from wild date palm (*Phoenix Sylvestris*) in India, from sugar palm (*Caryota Urens*) in Madras, and Ceylon, from palmyra palm (*Borassus flabelliformis*) in Burma and Madras, from nipa palm (*Nipa fructicans*) in the Philippine Islands, from the aren palm (*Arenga saccharifera*) in the Dutch East Indies and from the cocoa-nut palm (*Cocos nucifera*) in many tropical islands.

However, the two most important sources of the world's sugar production are cane and beet, and our discussion will necessarily be limited to these two. It may be noted here that all statistics on sugar embrace only beet and cane, because the quantity from all other sources is insignificant in comparison to those from the two main sources.

HISTORY OF CANE :—It is practically admitted by all authorities that India is the birth-place of the sugar cane. It was in India that sugar was first recognized in the cane, which

resulted in the methods for extracting juice from it. Finally, it is universally admitted that sugar was first crystallized in this country.

The very name of the product is of Indian origin. "Sarkara" in Sanskrit and "Sakkara" in Prakrit. Thence it is traced through all the Aryan languages, as "Schakar" in Persian, "Sukkar." in Arabic, "Suicar" in Assyrian and Phoenician, "Saccharum" in Latin, "Azucar" in Spanish and Portuguese, "Zuchero" in Italian, "Sucre" in French, "Zucker" in German and "Sugar" in English.

When it was first introduced into the Mediterranean countries from India by the Arab traders, the Greeks and the Romans termed it "Indian salt" and "Sweet salt". They obtained it in small quantities at great cost from India and used medicinally.

The cultivation of sugar cane, first introduced into the Mediterranean basin about the 5th or 6th century after Christ, spread in to Sicily, Spain, Madeira, and thence to West Indies, and to almost the whole Continent of South America until to-day it has firmly established itself in all the tropical and subtropical countries and islands of the world.

HISTORY OF BEET:—Marggraf, a German Chemist, was the first to discover in 1747 that the Silesian beet contained from 5 to 7% of sugar which was similar to that extracted from cane. He was successful in extracting and crystallizing small quantities of beet sugar in his laboratory. His discovery remained unnoticed for many years until his pupil, Achard, cultivated beet roots on his own estate in Germany and built the first beet factory in 1799, producing about 6 tons of sugar per year at a cost of about £ 13/- per cwt. This led King Frederick William of Prussia to finance and build several factories in 1801. Shortly

afterwards, the British declared a blockade against France, and Napoleon, recognizing the possibilities of the new beet sugar industry, ordered 70,000 acres in France to be planted with beet in 1811. He also founded numerous schools for instruction in the art of sugar-making.

At this early stage the percentage of sugar in the beet was only one-half of that in cane, and the extracted beet juice had an abundance saline impurities which prevented the sugar from crystallization. Therefore, scientific men throughout Europe devoted their attention to the improvement of the plant and as a result the average sugar content of the beet was raised from 6% in 1747 to about 15% at present, while the average percentage of sugar in cane stands now at 13%.

Science was first applied to the cultivation of beet and to the manufacture of sugar therefrom, while the cane sugar industry was still being carried on in the crudest possible way. The production of sugar from beets began to rise rapidly and spread all over Europe—Germany, Austro-Hungary, France, Belgium, Holland, Russia, Sweden, Denmark, Italy, Spain, Switzerland, Bulgaria and Roumania during the latter half of the 19th century. Towards the end of the century it spread to the United States and is now firmly established in the States of California, Oregon, Washington, Utah, Idaho, Colorado, Wyoming, Nebraska, Wisconsin, Ohio and Minnesota.

Along with the intensive application of science to the beet sugar industry there was still another factor that stimulated its development to the detriment of the cane sugar industry. Germany, Austro-Hungary and France initiated the bounty system, by which sugar was sold in those countries at very high prices, while the exported sugar was sold in foreign territories at less than cost. These two factors combined to increase the output of beet sugar in Europe and for some years

in the last century the world's needs for sugar were contributed half and half by the two main sources. For one or two years beet sugar even went over half. Then, the Brussel's Convention put a stop to the bounties. German and Austro-Hungarian manufacturers took another leap in the game and combined in cartels and kept up the unfair competition by dumping sugar at less than cost in the foreign markets, especially in Great Britain, the United States, India and Turkey.

In the meantime, the cane sugar industry all over the world was alarmed and it realized that it must introduce science in agriculture and manufacture. Java was the first to import first-class scientists from Holland. Hawaii came next and with the usual American enterprise increased the yield of cane per acre and extracted every possible ounce of sugar from cane. The scientific methods have also effected great economies in the cost of production. Science alone has saved the cane sugar industry from ruin which was imminent due to the unfair competition of particularly Germany and Austro-Hungary.

The World's Sugar Crop :—(a) BEFORE THE WAR :— Except in abnormal times like the last great war production has always kept pace with the demands of the world. With the rise in the standard of living the world over, consumption per capita in every country had been increasing up to the year, 1914, when the war in Europe began. In that year the world's sugar crop reached the highest level—little short of 19 million tons, to which the beet countries contributed 8,700,000 and the cane countries 10,300,000.

Of the cane sugar countries the biggest producers are India, Cuba and Java. There was a time in the 19th century when India used to export sugar to Great Britain. It amounted to about 28,000 tons in 1874-1875 which gradually fell down to 15,666

tons in 1878-79 and then lower and lower until in recent years prior to the war, instead of exporting, she has been importing white cane crystals from Java and Mauritius; and refined beet sugar from Germany and Austro-Hungary, and other European countries, in all about 755,000 tons in 1914. It was in this year that India lost her first place among the cane sugar countries, the total production being 2,460,573, while Cuba's figure went up to 2,592,667.

In the matter of yields per acre, while with the application of science and organization Hawaii produces on the average above 10,000 lbs., Java 8,000 lbs., Cuba 4,500 lbs., Formosa 3,400 lbs. and Louisiana 2,500 lbs., India yields only about 1,700 lbs. The methods employed both in agriculture and manufacture are very crude in our country and entail not only losses of sugar but of all the valuable by-products as well. I will take this up in detail in the third of this series and show how our land is being impoverished and how we can increase the wealth of the country by the application of modern efficient methods which have proved successful in other countries.

(b) AFTER THE WAR:—The world war has radically changed the situation in this country as well as in many others. The principal beet sugar countries of Europe were affected by the war and consequently the world's output of beet sugar became less and less until it stood at 3,947,501 tons in 1918-19, while the same war conditions stimulated production in the cane sugar districts, first because they lie outside the war zone and secondly because the larger profits derived from the higher prices during the war and after have been steadily employed in improving both agriculture and manufacture.

The following table shows vividly how the status of cane and beet output has changed during the last six years. It is estimated by Willet and Gray, the famous sugar authorities of

New York that the increase in the world's sugar production over the 1919-20 crop just finished will be 1,774,676 tons. But still there will be a great deficit of about two millions tons in comparison with the output of 1913-14.

Table No. 1 World's Sugar Crop.

Year.	Cane.	Beet.	Total.
1913-1914	10,284,014	8,699,466	18,983,480.
1918-1919	11,990,478	3,947,501	15,937,979.
1919-1920	11,952,296	3,358,528	15,310,824.
1920-1921 (estimated)	12,580,500	4,505,000	17,085,500.

The countries most affected are Germany, Hungary and Austria, France and Russia. While the total output of European beet sugar was 8,039,230 tons in 1913-14, the estimated figure for 1920-21 is only 3,520,000 tons. Hence Europe is still short by over 4½ million tons.

THE FUTURE OF THE WORLD'S SUGAR INDUSTRY:— Conditions in Europe are still unsettled and no one can tell with any accuracy how long it will be before the affected countries settle down to normal business. France's beet district was practically destroyed by the German army of occupation, and statistical experts claim, it will be another six years before France can attain her pre-war normal condition. Germany is not planting any more than is necessary for home consumption. Austria and Hungary have to import for their home markets. They are financially in a very deplorable condition and cannot possibly rehabilitate their industries for many years. Russia is busy with internal troubles which, for various reasons, will take quite a while to settle. Only Belgium and Czecho-Slovakia have picked up and are producing their pre-war tonnage. The other European countries not involved in the war have no room for expansion.

Of the cane sugar countries; Java, the Hawaiian Islands, Formosa, the Philippines and a few other minor districts have attained their maximum. The British West Indies, Fiji and all other places employing Indian indentured labor; are finding it hard to carry on without this class of cheap labor. Mexico is still unsettled. The only principal countries that are capable of expansion are Peru, Brazil and India.

INDIA'S OPPORTUNITY:— India is the most important and unique of all, because here we have not only the possibility of increasing production from the present area of 3 million acres but also the splendid opportunity of bringing hundreds of thousands of acres of forest land under cultivation. With the introduction of large central factories on the most up-to-date lines we can easily produce 6 million tons of pure white sugar from the present acreage even without improving agriculture. The improvement of agriculture will be matter of course and possible only with the cooperation of the central owners who will have money and scientific staff at their disposal. These latter, the present small land-holders cannot afford to have. With the adoption of better agricultural methods the yield per acre will still be increased. But, assuming we produce no more than two tons of sugar per acre, six million tons will supply the demands of the country, stop imports absolutely and furnish a surplus of at least one million tons for export after making allowances for the gradual increase in consumption per capita.

Besides cane sugar there is ample field for the manufacture of sugar from beets in the North West Frontier Provinces and Kashmir. The climate up there is ideal for cultivation of beet. Beet sugar in that part of the country should find a very favorable market in that territory and in the contiguous foreign territories beyond the Frontier.

Second in importance to cane sugar at present in India is that obtained from date palm. It amounts to nearly 500,000

tons a year. The present system of manufacture is just as crude as that of cane sugar. There is plenty of room for improvement and expansion of this industry in Bengal, Madras and Central Provinces. Date sugar, when properly produced in modern factories, will play a more important part in the Indian sugar market than at present.

It is our good fortune that, after all the talk of Swadeshi that started in Bengal in 1905 and that sent hundreds of us Indians to study industries in foreign countries, India is beginning to think on the lines of industrial development. Sugar is a very necessary industry and will benefit our country in many ways. There are undoubtedly many difficulties in our way as there are in any new adventure. But they are not insurmountable, as we are quite willing to benefit ourselves by the accumulated experience of the rest of the sugar world, particularly of Hawaii and Java in cane sugar and Europe and America in beet sugar. Proper organization and cooperation will help in this industry as well as in others. Once the Indian capitalists know the amount of money there is in sugar, factories will multiply all over the country and the present vertical cane mill and the open kettle will be things of the past in our lifetime. It is not too much to predict that India will be the dominant figure in the world's sugar market before the next quarter of the century is over.

II. The Economics of the Production of Sugar and of the Utilization of its by-Products.

AGRICULTURE OF CANE:—Cane is a tropical plant, but thrives well also in sub-tropical countries under favorable conditions. A warm and moderately moist climate, with intervals of dry heat, is most suitable for its growth. The amount of heat received by the plant influences the rate of growth, the time it requires to mature, and its composition.

SOIL :—Under natural conditions a typical clay soil, that has considerable water-retaining power is the best. Loams and alluvial deposits are considered to be second in importance. Last come the lighter sandy soils that have no water-retaining power. At the same time these sandy soils give enormous yields under ample irrigation and intensive fertilization. The best examples of these soils are Peru and Hawaii.

The complex nature of the soil for the cultivation of cane could not be better stated than what Boname observes* : “The cane grows more or less well in all soils if it receives the care and manures that its economy demands ; but to develop vigorously, and to supply a juice rich in sugar, it demands a free and deep soil. The physical properties of the soil are at least as important as its chemical composition ; and if irrigation is impossible during the dry season its coolness will naturally be one of the principal factors in the production.

“ The most favorable nature of the soil varies with the climate.

“ When rain is abundant the soil should be light and porous ; if rains are scanty a too light soil will dry rapidly, and vegetation will be checked, the cane will not completely die, but in place of giving large stalks, rich in sugar, it will produce small, dry, hard and woody stalks. With a relatively dry climate a heavy soil will give good returns if the rains are evenly distributed.

“ With a rainfall of 197 to 236 inches a sandy soil draining easily, will give an abundant return with a high consumption of manure. A clay soil, especially if it is situated on a plain, will be constantly saturated with stagnant water, which will prevent the aeration of the soil ; canes will develop feebly, and their roots will rot little by little, leading to the death of the stalk.

* Deern, Noel :—Cane Sugar, pp. 45-46.

“Some alluvial earths produce a luxuriant vegetation in wet years. The canes are very fine, but very watery.

“Other things being equal, a calcareous clay soil, not exceedingly light will give sweeter canes than a clay containing vegetable debris, but the yield will be generally less abundant. If the rains are sufficient and conveniently divided, returns both for the cultivator and for the manufacturer will be excellent. If the season is wet, the advantage will remain with the lighter soils, whilst if it is dry, the canes will suffer much and will afford stunted and woody stalks.

“High and almost constant results will be obtained with irrigation and porous soils; for the growth can be regulated at will, and conducted in a fashion so as to obtain the maximum cultural and industrial return, promoting the size of the cane and its leaf development in the first stages of its growth and without intermission, until the time arrives when it is necessary to develop the juices formed at an early stage”.

SEED:— This is the most important aspect of the agriculture of cane. This plant is very susceptible to diseases and pests, and as the seed for planting is obtained from the matured cane stalks, naturally if the particular variety has begun to deteriorate on account of a certain disease or pest, it becomes worse from generation to generation until the crop spells total ruin to the cultivator. Such a condition exists almost all over India at the present time.

It has been the experience of all the cane countries that the old indigenous varieties have become diseased and had to be replaced by new seedling varieties imported from other countries. The imported varieties are acclimatized and cross-bred with the indigenous ones. Such work is being constantly carried out in the experiment stations of Hawaii, Louisiana, Porto Rico,

Cuba, Argentina, Formosa, India and other countries. A staff of scientists are carrying on work in these stations and always keep new varieties to take the place of the old ones that begin to show signs of decay.

MANURING:—Manuring along with liming is not only necessary to replenish the soil from which plant food is constantly being removed by the crop, but is also employed to increase the yield. It includes not only farm yard manure, but also commercial fertilizers, such as, nitrates, superphosphates, bone manures, oil cakes etc., as well as green manure (leguminous crops grown between the cane rows and turned under, when mature, by means of a plow). Lime is a very necessary adjunct to the fertilizers added to a cane soil. It improves the physical condition of heavy soils by loosening them. It corrects the acidity of soils and renders potash available. In a modern cane sugar factory one of the by-products is press cake which is mostly lime and is applied to the fields before plowing. It amounts to about 5,600 pounds per every 100 tons of cane crushed and goes back to some three acres of land from which the cultivator harvested this cane.

IRRIGATION:—In tropical countries with little rain, irrigation becomes absolutely necessary in order to supplement the deficient rainfall. The four main sources of water for irrigation purposes are :

- (1) Reservoirs built on the mountains to catch all the water during the rainy season. These are connected by ditches with the fields.
- (2) Upland streams which are diverted into the plantations in the low lands.
- (3) Canals which carry the water from large rivers nearby.
- (4) Wells and rivers from which water is pumped.

In the Hawaiian Islands enormous sums of money are invested in irrigation projects by private Corporations which control their own systems. The total capital invested in irrigation systems in Hawaii, which has about 60,000 acres under irrigation, is in the neighbourhood of four crores of rupees. The average cost of irrigation including labor per acre is a little over Rs. 200/-. Such a large amount appears prohibitive, but it must be borne in mind that in these islands the average return per acre on unirrigated plantations is about three tons of sugar, and on the irrigated plantations about six tons, so that three tons of sugar less cost of cutting, transport and manufacture, are to be credited against Rs. 200/- as the cost of irrigation.

In Hawaii, as a general rule, 1,000 pounds of water are required per pound of sugar produced. This refers to natural as well as artificial supplies combined. During its seventeen months of growth in Hawaii a cane crop receives about 100 inches of water, 27 inches of which is rainfall.

HUSBANDRY OF CANE :—There are many manual implements used in those districts where labor is plentiful and consequently cheap. But in most districts, especially in Hawaii, animal and power implements are employed. The chief manual implements are those used for hoeing and weeding.

Among the animal and power implements the most important are the steam gangplows, turn,-or mould-board, shovel and disc plows, harrows, tongue and disc cultivators. Some of these are essentially necessary for deep plowing, the steam plow going as deep as 28 inches (which facilitates the deep root system reaching the sub-soil water and aeration). The turn-board plow is used for turning the soil upside down and preparing it for planting by making the furrows in which cane is planted. This is also used in opening irrigation channels and in turning over weeds between the rows of young canes. The disc plow is

employed for furrowing, but more extensively for turning over and burying the pea vines growing as a green manure.

The cultivator is drawn by animal power between the rows of cane, breaking up the soil and at the same time destroying the weeds. The harrow finds its use for reducing the soil, after cultivation, to a fine tilth and for breaking up clods and levelling inequalities.

PLANTING OF CANE :—After the soil has been well prepared, the seed cane is planted in the furrows. The width of the furrows varies from three to seven feet depending upon the fertility of the soil. The more fertile the soil the wider apart the rows are in order to allow freedom of growth to the luxuriant crop.

CULTIVATION :—Cultivation of the fields is carried on, from time to time, to destroy the weeds. This operation is continued until the plant is too big to let the animals pass through the rows without injuring them. In dry seasons irrigation water is given once or twice a week according to the demands of the plant.

HARVESTING OF CANE :—The cane is harvested for the factory at a time when there is a minimum of, or even no, reducing sugars, and when it is at its maximum purity. The chemist, by making occasional analyses, determines the right time for harvesting. This is very important, as the lower the percentage of reducing sugars, and the higher the purity, the more sugar can be crystallized. After this right time the cane sugar breaks up into reducing sugars resulting in a loss of the marketable product.

The general practice in the Hawaiian Islands now is to burn the cane before cutting. Stripping is the universal practice followed from ancient times and still prevalent in many countries. But it has been found in Hawaii that there is no deterioration of sugar due to burning, provided the cane is crushed within 24 to

36 hours. The advantages of burning are (1) the saving of the laborious work entailed in stripping and (2) Killing of most of the insects that may be breeding in the field.

TRANSPORTATION:—There are various methods of transportation, depending on local conditions. The principal ones are light railways. Cane grown on very high elevations, where the railroad cannot be taken economically, is sent down to a lower elevation through flumes and then transported by the plantation railway to the factory. Among other means of transportation are the use of animal power and mechanical traction on roads, and of aerial ropeways for crossing deep gulches. In certain localities where cane is the principal industry the public railroads are utilized to transport large quantities of this material.

UNLOADING THE RAW MATERIAL:— The loaded car is first weighed on a weighbridge. There are many mechanical devices employed for unloading cane, one of which is the rake system. One man manipulates the machine which is situated on one side of the cane carrier, while on the other side, directly in front of the machine, stands the loaded car. The rake attached to the machine is so arranged that it travels the whole length, breadth and depth of the car. It rakes off the cane sticks into the carrier which is an endless belt made of steel or wooden slats and moves on a lower elevation at the bottom of a chute and delivers the cane to the crusher. The empty car is pushed forward and transferred to another track where it is weighed again.

From these weighings the gross weight of the cane is obtained. There is still a considerable amount of trash attached to the cane, which is determined by a number of experiments. The gross weight minus the weight of trash gives the net weight of the cane entering the factory.

MANUFACTURING METHODS:— There are two main ways by which white sugar is obtained from cane. The first of these consists of manufacture of raw brown sugar in the tropics, and its refining in central locations with the use of bone char which gives the finest white sugar demanded by American and most European markets. To obviate this double operation and to be independent of the refiner several cane countries manufacture white sugar directly from cane to meet the demands of certain markets that are satisfied with this grade of sugar. This second method is prevalent mostly in Java, Mauritius, Natal and Louisiana. For the sake of convenience in this paper the two methods will be named (1) American and (2) Java. The principal difference in the manufacture of raw and plantation white sugar lies in the treatment of the juice, the other processes, such as milling, filtration, evaporation, graining and purging remaining the same.

(1) **AMERICAN METHOD:—**Cane is the raw material and has now entered the factory. The object of the manufacturer is to obtain the maximum amount of sugar out of it. The following is an average analysis of cane :— *

Table No. 2. Composition of Louisiana Cane.

Constituents	Percentage.
Water	74.50
Ash	0.50
Fiber	10.00
Sugars	14.00
Fat and wax	0.20
Pectin (gums)	0.20
Free acids	0.08
Combined acids	0.12
Nitrogenous bodies	0.40
Total...	100.00

* Spencer, G. L.—Handbook for cane sugar manufacturers, 50.

MILLING OF CANE:—The whole cane on its way to the crusher is cut into very small pieces by knives revolving at the rate of more than 500 revolutions per minute. In some factories it goes through a shredder which shreds it into a fine looking excelsior.

The crusher consisting of either two or three rollers extracts most of the juice. The bagasse from the crusher goes through two, three, four or five subsequent mills. By multiple crushing and compound maceration much more juice is extracted than is possible in a single mill. There are factories that have as many as seven mills of three rollers each, grind 2,000 tons of cane in 24 hours, and extract 99% of the sugar present in the cane.

The exhausted bagasse is conveyed by a carrier into the fireroom where it is used as fuel to convert the water into steam for driving the engines and for evaporation and boiling purposes. In a well-managed factory the bagasse should be sufficient to furnish the needed fuel.

The juice from the mills comes to a supply tank and is measured or better still, weighed. This is called raw juice and contains, in addition to water and sugar, a certain percentage of the impurities of the cane.

CLARIFICATION OF THE RAW JUICE:—The juice then goes through a heater which raises the temperature to over 100° C. Then it is limed and allowed to settle. The decanted juice is ready for evaporation and goes to the evaporator supply tank. The scums or mud are forced through filter presses which separate the liquid from the solid. The filtered juice is conducted into the evaporator supply tank; and the presscake containing from 0.5 to 1% sugar on its own weight, is dropped down into empty railroad cars and applied to the cane fields.

EVAPORATION OF THE CLARIFIED JUICE:—This operation is carried on in multiple-effect evaporators where the juice which

originally contained about 85% water comes out as syrup containing only 25% water. Unlike open kettle boiling there is no loss of sugar in this operation; and the heat applied is utilized to the fullest extent, as the vapor from the first effect serves to heat the second effect and so on.

SUGAR BOILING :—The graining of the sugar in the syrup is done in vacuum pans. The syrup is boiled under vacuum until the required grains are formed. The boiled material which is called "massecuite" and contains sugar crystals and "mother liquor" is discharged into mixers.

THE SEPARATION OF THE CRYSTALS :—The massecuite flows from the mixer into centrifugal machines which separate the crystals from the molasses. The sugar crystals remain inside the basket and the molasses goes out through gutters into a tank.

CURING OF SUGAR :—The centrifugal machine discharges the sugar into a conveyor underneath where it is carried along a helicoidal screw into a bucket elevator which takes it up to the top floor and drops it on a hopper. From the hopper it falls down into a large storage box whence it comes down by gravity into an automatic scale and weighed in bags. This long operation is carried on in order to give the hot sugar a chance to cool down before it is bagged. The hopper breaks up the big lumps, if any are present.

BAGGING OF SUGAR :—One man bags the sugar dropping down from the scale. Another man carries the bag through an electrically driven sewing machine and drops it into an inclined elevator ending with a horizontal belt which is so arranged as to take the bags into any part of the sugar warehouse.

THE FINISHED PRODUCT :—It is commercial brown sugar containing 96% pure sucrose, from 1.0 to 1.5% moisture, the rest being organic non-sugars and inorganic matter. This sugar is

sold to the refiners on the mainland of the United States who whiten it by putting it through bone char.

WORKING UP OF THE UNEXHAUSTED MOLASSES:—The molasses coming from the centrifugal machine still has a considerable amount of sugar and is, therefore, boiled over into grains, cooled in motion in crystallizers and purged in No. 2 centrifugal machines from which No. 2 sugar and No. 2 molasses are obtained. The No. 2 sugar which is a low grade product containing about 80% sucrose is either used as seed grain to build the first sugar on, or remelted and mixed with fresh syrup in certain proportion.

THE DISPOSAL OF NO. 2 MOLASSES:—This is called exhausted molasses which contains from 30% to 35% sucrose. However, this sugar cannot be economically crystallized, because of the presence of the various organic and inorganic impurities which prevent the sugar from crystallization.

It is generally sold to the distilleries which produce alcohol from it. Some of it is mixed with chopped alfalfa, or very fine bagasse, or ground barley and fed to the cattle.

RECOVERY OF SUGAR FROM CANE:—A modern factory equipped with efficient machinery and apparatus and having scientific control should recover about 90% of the sugar in the cane into the commercial product. That is, assuming the sugar content of cane at 13.0%, 11.7% should be recovered in the commercial sugar. The balance of 1.3% is lost in the bagasse, press-cake, molasses and undetermined losses. Expressed in another way, 8.5 tons of cane should produce a ton of raw sugar.

REFINING OF RAW SUGAR:—It is the final stage in the production of white sugar according to the American method. The raw brown sugar is transported from the tropics to the Pacific and Atlantic sea-boards of the United States and sold to the great refineries that melt from 1,000,000 to 4,500,000 pounds per day of 24 hours.

The Process of Refining Consists of the Following Operations:—

(a) **AFFINATION**:—Washing of the raw sugar in centrifugal machines to remove the molasses adhering to the crystals.

(b) **MELTING**:—Dissolving the washed sugar in water to make a syrup which is called “liquor” in refineries.

(c) **FILTRATION OF THE LIQUOR**:—Separation of the insoluble and suspended impurities through bag filters.

(d) **FILTRATION THROUGH BONE CHAR**:—which bleaches and purifies the liquor.

(e) **BOILING THE LIQUOR**:—in vacuum pans to form grains.

(f) **CENTRIFUGALLING**:—Separating the crystals from the mother liquor in centrifugal machines.

(g) **DRYING THE SUGAR CRYSTALS**:—in inclined dryers.

(h) **GRANULATING**:—Sorting the crystals into different sizes through different-mesh sieves in granulators.

(i) **PACKING**:—in bags, barrels, or boxes as the trade demands.

Besides granulated sugar of varying sizes the refineries also turn out cubes and dominoes used in tea, coffee and chocolate. This sugar is the same as obtained from (f) and is moulded in special machines and dried in hot-air ovens. The refinery molasses are passed through bone-char resulting in a golden yellow syrup used for table purposes.

RECOVERY IN A REFINERY:—The best raw sugar for refining purposes is one of 96 polarization (i. e., containing 96% pure sucrose) and having hard and evenly large grains. One hundred

tons of such sugar, has 96 tons of pure sucrose entering the refinery. An American refinery records the following recovery and loss:—

Table No. 3 Recovery in an American Refinery.

	Tons	% on sucrose in raw sugar.
Refined sugar of 100 polarization ...	93	96.9
Sucrose in golden syrup ...	2	2.1
Sucrose losses ...	1	1.0
Total	96	100.0

(2) **JAVA METHOD:—**This method eliminates the bone-char refinery and manufactures granulated white sugar directly from cane juice by chemical processes of juice treatment. However, the sugar is not as white and dry as the bone-char refined sugar.

As stated before, the Java method is the same as that of manufacturing raw sugar except in the treatment of the juice. In the manufacture of direct white sugar which is also called "plantation white sugar" the purification of the juice has to be more thorough in order to produce a colorless liquor. The two standard processes employed are:—carbonation and sulphitation.

(a) **CARBONATION PROCESS:—**This process was first introduced in the beet-sugar industry and perfected before it was applied to cane sugar. The juice is first limed to excess, and calcium oxide partially neutralized by carbon dioxide gas, leaving the juice slightly alkaline. The precipitate is separated by filtration. The filtrate is again neutralized by carbon dioxide gas, leaving juice faintly alkaline to phenol-phthalein. The precipitate is removed by second filtration. Final alkalinity is neutralized by sulphur dioxide gas. This gives a colorless juice which goes through the evaporators, vacuum pans and centrifugal machines,

(b). **SULPHITATION PROCESS**:—The raw juice is limed to excess and the excess of lime is nearly neutralized by sulphur dioxide gas. It is then heated to boiling point and subsided in subsiding tanks. The subsided clear juice goes to the evaporator. The sediment goes to the filter presses and the filtered juice passes to the evaporator. The remaining operations are the same in principle as in raw sugar manufacture.

BEET SUGAR.

AGRICULTURE OF BEET:—The sugar beet thrives well in temperate climates in good sandy loam soil. Under favorable conditions of climate and soil it needs very little irrigation. The soil should not be too light. Deep cultivation is essential for the normal development of the tapering roots.

In the United States the ground is well-prepared and beet seed is sown in rows by means of drillers. The plants come up thickly, and when they are some three or four inches high, they are thinned out by hand, so that the plants are about 10 inches apart in each row. The rows are 14 inches apart.

The fields are then hoed by hand two or three times to keep the weeds down and cultivated between the rows in order to conserve moisture.

Seeds are planted from January to April. The maximum of sugar is stored up in from seven to eight months. Harvesting continues from July to November. At harvest-time, the soil is loosened by running a plow along the rows, which makes it easier for the laborers to lift the beets by hand. Then the tops are cut off and the roots are sent to the factory.

MANUFACTURE OF SUGAR FROM BEET:—The beets from the field of each farmer are weighed and sampled separately. The farmer is paid on the basis of this weight and the analysis.

They are fed into the factory hydraulically which cleans most of the dirt attached. They are then scrubbed by revolving brushes in a drum in order to remove the remaining dirt, and weighed automatically. The next operation is that of cutting into small chips called "cosettes". The cosettes are immersed in hot water in a diffusion battery, and the sugar diffuses from the plant-cells until it is equally distributed between the water and the beet juice. A diffusion battery consists of a number of round vertical cells, preferably about twelve in number, which are filled in turn with cosettes. Water is introduced into No. 1 cell under pressure, and flows from cell to cell, extracting sugar from the cosettes. The juice resulting from this operation is called "diffusion juice".

The diffusion juice contains, besides water and sucrose, several acids, nitrogen compounds, coloring matters, other organic non-sugars and mineral matters. It is not fit for drinking as cane juice is. The object of the manufacturer is now to eliminate all the impurities and turn out a pure white sugar which will have the same physical and chemical properties as the refined cane sugar.

CLARIFICATION OF THE DIFFUSION JUICE:—Double carbonation process is employed and consists of the following operations:—

- (a) **LIMING:—**The juice is limed to strong alkalinity.
- (b) **FIRST CARBONATION:—**Carbon dioxide gas is injected into the limed juice until it is faintly alkaline.
- (c) **FIRST FILTRATION:—**The precipitate is filtered through filter presses.
- (d) **SECOND LIMING:—**The filtered juice is pumped through a juice heater which raises the temperature to boiling point. Some more milk of lime is added.
- (e) **SECOND CARBONATION:—**The juice from (d) is carbonated again.

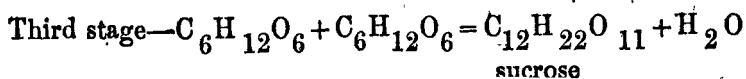
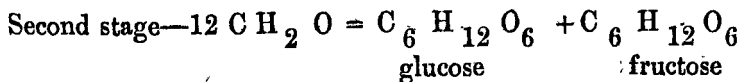
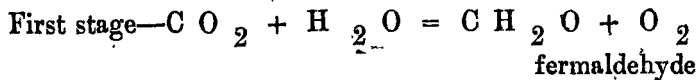
(r) SECOND FILTRATION:—The precipitate, which is about one-third of that from first carbonation, is separated in the second filters.

The clear juice is then evaporated in the multiple-effect evaporators and comes out as syrup. The syrup is boiled in vacuum pans giving what is called in the beet sugar industry "fillemass." The "fillemass" is purged in centrifugal machines giving white sugar and "green syrup" which is re-boiled.

THE ECONOMICS OF THE TWO INDUSTRIES :

We have seen how sugar is produced from cane and beet. In considering the economics of these two industries one is at once struck with the unique fact that unlike other human foods obtained from either vegetable or animal sources, pure white sugar, which is palatable and at the same time gives the best results in the human body, does not contain anything that has been taken from the soil. Pure sucrose consists of carbon, hydrogen and oxygen. The first is obtained from the air in the form of carbon dioxide. The elements, hydrogen and oxygen, are drawn by the plant in the form of water from the soil. This water also previously existed as vapor in the atmosphere.

The method of manufacture of sucrose in the plant is not yet proved. However, its formation from carbon dioxide and water may be represented thus:—



The cane and the beet however take out plant nutrients from the soil which must be returned in order to maintain the normal productivity of the soil. These nutrients—nitrogen, potash and phosphoric acid—along with the added ingredients during the manufacturing process in the factory, remain in the by-products which are utilized to the fullest extent.

THE BY-PRODUCTS OF THE CANE INDUSTRY:—Every 100 tons of cane, depending on the quality of the cane and on the efficiency of manufacture, gives from seven to twelve tons of sugar and the following by-products:—

(a) 25 tons of bagasee which is mainly used as fuel, but which, if turned into paper pulp, will yield at least six tons of bleached pulp. Before deciding on a pulp mill to be attached to a sugar factory it is essential that the value of the fuel to be substituted and its steady supply in the particular locality should be thoroughly studied.

(b) $2\frac{1}{2}$ tons of filter-press cake, which contains most of the lime added in the manufacture, is used as a fertilizer in the fields.

(c) Three tons of molasses which will yield (i) about 150 gallons of a specially prepared alcohol used as the best substitute for petrol in internal combustion engines, and (ii) the fertilizing elements nitrogen, lime, phosphoric acid and potash. Potash is the most important and is present in large quantity. The yield of potash from the above three tons of molasses is from 200 to 270 pounds. The complete utilization of this by-product—molasses—right on the plantation is the most desirable thing. A large plantation will have a number of tractors, trucks and automobiles which will utilize a considerable part of the motor fuel manufactured. The more important point is that the valuable fertilizing elements will be returned to the soil. Molasses sold to an outside distiller means the loss of the fertilizers as far as the plantation is concerned.

Germany always excels in this sort of national economy. It is said that she never exports anything that impoverishes the soil. She used to export sugar but no molasses, for she early encouraged the production of alcohol for fuel on the farm, and all the fertilizing material was returned to the soil where it originally came from.

Another by-product is "molascuit" which is a mechanical mixture of very fine sifted bagasse and molasses. It is a very good cattle food, but does not contemplate utilizing all the molasses produced.

The by-products of the beet-sugar industry—Every 100 tons of beets, depending on the sugar content of the beets and efficiency of manufacturing methods, yields from 12 to 16 tons of sugar and the following by-products:—

(a) Six tons of dried pulp used as cattle food or tons of sweet pulp when mixed with molasses, also used as cattle food.

(b) 10 tons of filter press cake used as fertilizer.

(c) One ton of molasses which is mixed with the pulp as above or used to produce alcohol. In the latter event the potash and nitrogen are recovered and returned to the soil.

(d) The waste waters from Steffen's Sachharate process are concentrated and evaporated to dryness in a vacuum apparatus. It is mixed with slaughter-house waste, and applied as fertilizer.

We see from the above study of the recovery of sugar and of the utilization of by-products that nothing is lost. We have seen not only how all the values can be realised but also how agricultural economy can be effected by returning the fertilizing elements to the soil. In modern industrial processes the by-products are as important and valuable as the main product. The sugar industry is no exception and, if properly organized, brings

immense benefits to the investors as well as the particular community. As will be seen from the following paper, it will accomplish all this in India without introducing the evils that go with city industries.

III. The Need of Science and Organization :

How Hawaii and Java have Solved their Problems.

The establishment of the cane sugar industry on the basis of large-scale production in central factories in India undoubtedly presents many obstacles. They are, however, by no means insurmountable, if we are willing to profit by the experiences of other cane countries that have spent years of patient and pains-taking work and built up their present prosperous condition through many stages of development. Science and organization are the two pivots on which Hawaii and Java stand to-day. There is many a lesson for us to learn from these two countries.

The first and foremost of these lessons is that we should not commit the same mistakes as they had. It is a waste of human energy and of money to duplicate mistakes. Of course, it is not advisable nor is it possible to copy everything. Each country has its peculiar conditions which will not permit of wholesale imitation; but the fundamental principles should be well understood and adapted to the Indian conditions as far as possible.

LARGE-SCALE PRODUCTION:--Is the prevailing order in all other countries. Twenty-five years ago most of the Hawaiian Factories were very small, producing ten or twelve tons of sugar a day. To-day the majority of them are producing over one hundred tons per day, the daily output of the largest one being 400 tons. Cuba has still larger factories manufacturing as much as 800 tons of sugar in 24 hours.

The central system of sugar manufacture in the Philippine Islands is a matter of the last ten years. American enterprise introduced Hawaiian methods into the Philippines from the very beginning. During the last five or six years some sixteen centrals have been built, twelve of which have a daily output of from 100 to 220 tons each.

There are several instances in Hawaii where four or five small factories have been consolidated into one, thereby cutting down the cost of production and making it possible to introduce more modern machinery and apparatus and to improve general efficiency.

CHEMICAL CONTROL OF MANUFACTURE:—It was only a quarter of a century ago that a chemist was unknown on the plantations of Hawaii. The Planters used to take a chemist from San Francisco who would test a few samples of cane, tell the planters that it was ripe, and return home. They just weighed their cane and sugar. In the absence of a chemist they did not know the quantity of sugar entering the factory in the cane. No analyses were made of the intermediate products nor of the by-products, so that they might determine the losses in manufacture. To-day there is not a single mill that does not have a well-equipped laboratory with two or more chemists whose duty it is to keep down the manufacturing losses at a minimum, and to watch the quality of sugar all through the twentyfour hours of operation. They are also improving methods of manufacture, effecting economies in steam consumption and solving many research problems that arise on the plantation.

EFFICIENT DIVISION OF LABOR:—The most up-to-date cane countries practise efficient division of labor and employ large staff on high salaries to supervise the work of the different departments. Table No. 4 will give an idea of the sort of salaried staff that a typical Hawaiian plantation employs all through the year;

Table No. 4:—Executive Staff of a Typical Hawaiian Plantation :

Designation.	Duties.
General Manager.	} Responsible to the Board of Directors for all the agricultural and manufacturing operations.
<i>Agricultural Department:—</i>	
One Assistant Manager	—Supervision of the Department.
Four Supervisors	} Supervision of the four sections of } 1,000 acres each.
One Civil Engineer	} In Charge of Surveys & Irrigation } projects.
One Mechanical Engineer	} In Charge of Steam Plows & } Tractors.
One Locomotive Engineer	} Supervision of the entire plantation } railroad.
One Chief Engineer	—In Charge of the pumping stations.
<i>Manufacturing Departments:—</i>	
One Superintendent	—Supervision of the entire factory.
One Chief Chemist	} In Charge of chemical control and } in the capacity of Assistant } Superintendent.
Two Assistant Chemists	} Each in charge of the laboratory } for twelve hours.
Two Mechanical Engineers	} Each in charge of the milling- } department for twelve hours.
Two Sugar Boilers	} Each in charge of the boiling } Department for twelve hours.
One Chief Mechanic	—Supervision of the machine shop.
One Chief Clerk	} In charge of the stores, warehouse } and purchasing supplies.
<i>Plantation Office:—</i>	
One Chief Book-keeper and Cashier	} Supervision of the entire office.

Four Assistants } In charge of cost accounting and
 } segregation of accounts.

Sanitation & Hospital Department:—

One qualified doctor } In charge of the hospital and
 } supervision of general health and
 } sanitation of the plantation.

One plantation crushing about 1,200 tons of cane per day pays out to its salaried employees over twenty-five thousand rupees a month. Such a sum becomes insignificant when one remembers that the cost of supervision is less than 5% of the total cost of production of a ton of sugar.

Without such a complete staff the production would be much less giving low profits and the plantation would run the risk of operating at a loss at times. These men do not simply draw their high salaries, but earn them by their knowledge and training and by constant hard work.

THE ROLE OF THE EXPERIMENT STATION:—One of the most unique institutions of the Hawaiian sugar industry is the Hawaiian Sugar Planters' Association which is a symbol of cooperation. It consists of 47 sugar-producing corporations in the territory. Prior to its organization there existed unfair competition in various ways. The different plantations were distrusting one another, and no single plantations could afford to employ a large staff of scientists to investigate various problems in agriculture and manufacture.

In 1894 this Association established an Experiment Station without any assistance from the then Government of Hawaii and purely on private initiative. At present the scientific staff consists of the following:—

Table No. 5:—Staff of the Hawaiian Sugar Planters' Experiment Station :

Designation.	Number.
Director	1
Chief Agriculturist	1
Assistant Agriculturists	4
Plant Pathologist	1
Assistant Pathologist	1
Chief Entomologist	1
Assistant Entomologists	2
Sugar Technologists	2
Chemists	5
Total...	18

The Experiment Station has 125 acres devoted to field experiments covering a wide range of subjects. It has issued many bulletins on agriculture, chemistry, entomology, and plant pathology and physiology which are distributed free among all the technical men of each plantation. It also issues a Monthly Record which contains all the work carried on by all the departments of the station and serves as a clearing house of information for the plantations. Since 1906 it has propagated over 20,000 seedling varieties in order to produce a cane that will resist disease, give a heavy tonnage per acre, have a higher sugar content and yield a purer juice. The planters claim "that the position of Hawaii as the most advanced sugar-producing country of the world is mainly due to the successful efforts of the Experiment Station in putting into practice the best methods of fertilizing and cultivating sugar cane, combined with improved methods of harvesting and milling." *

The maintenance of this Experiment Station costs the planters in the neighbourhood of four lakhs of rupées a year, each company annually contributing about ten annas per ton of sugar produced. It has prevented the loss of millions of dollars

* The Cane Sugar Industry—U. S. D. C. Miscellaneous Series, No. 53. page 70.

to the planters. Some years ago the leaf hopper began to ravage the fields of some of the plantations and was about to spread all over the territory. The Station sent out its expert entomologists all over the cane countries who took back with them a few egg parasites. These were liberated in the affected fields, and the spread of the leaf hopper was checked and kept under control. It is conservatively estimated that these results, in terms of money, have been worth over six crores of rupees to Hawaii.

The International Sugar Journal of London remarked at the time: "... .. To get these parasites and be absolutely certain that they are the right ones and might do what was expected of them, cost the sugar planters possibly one half of the per cent, of the above figure. Had the planters known where to go and what to look for, the parasite might have been obtained for a five-cent stamp, as a favor, from a scientist abroad. The moral is that the work of this exactitude and magnitude must have no 'ifs' to qualify results."

The Formosa Experiment Station has, by importing and introducing a new variety of cane, from Hawaii, increased the yield of sugar per acre by four times. The Tucuman Experiment Station has achieved similarly splendid results in Argentina where the soil was practically exhausted by taking off forty consecutive crops.

RESULTS OF SCIENTIFIC AND INTENSIVE CULTIVATION:—Intensive cultivation, judicious fertilization, and proper use of irrigation water, are at the foundation of increasing the productivity of the soil. All the cane countries, with the help of their experiment stations, have accomplished marvelous results. However, statistics are not available for most of the districts. The case of Hawaii is unique in this respect. Table No. 6 shows what has been achieved in those islands.*

* The Cane Sugar Industry—U. S. D. C. Miscellaneous Series, No. 53, page 119.

**Table No. 6:—Average Production in tons (2,000 lbs.)
of sugar per acre on 12 Representative Plantations of Hawaii,
1895 to 1914.**

YEARS.	Irrigated plantations :						Unirrigated plantations :					
	No. 1	No. 2	No. 3	No. 4	No. 5	No. 6	No. 1	No. 2	No. 3	No. 4	No. 5	No. 6
1895	2.6	5.1	4.1	3.8	4.7	2.6	2.9	2.8	2.5	2.6	2.6	2.5
1896	4.0	6.1	5.1	4.8	6.1	3.0	3.7	3.1	3.3	3.6	3.6	3.7
1897	4.1	7.3	4.5	5.4	6.7	5.7	3.9	4.3	4.4	3.6	4.3	4.1
1898	6.2	6.2	5.0	5.7	7.6	5.7	3.5	3.3	4.7	3.5	3.8	4.2
1899	6.7	6.2	6.1	6.1	7.2	5.2	4.1	3.9	4.8	3.0	4.0	4.0
1900	7.2	5.9	5.8	6.8	6.6	5.5	4.0	2.9	4.1	2.2	3.3	3.8
1901	6.4	5.7	3.5	6.4	7.2	4.5	3.6	3.3	3.5	2.7	3.9	4.1
1902	6.3	3.5	5.9	4.9	6.0	4.3	3.8	3.0	4.2	3.6	3.5	3.8
1903	6.9	5.0	7.9	5.9	5.0	5.6	4.2	3.7	4.6	4.2	3.4	3.6
1904	6.8	4.9	7.4	5.2	5.5	4.5	3.1	3.0	3.7	3.0	2.7	2.4
1905	8.2	5.8	8.5	5.9	6.7	5.0	2.0	3.3	4.2	3.2	3.2	3.3
1906	7.9	5.9	6.7	6.0	6.1	4.3	2.1	4.1	4.0	3.5	3.6	3.4
1907	8.0	5.2	6.6	5.4	6.1	4.1	3.8	3.7	3.8	4.0	3.5	3.0
1908	8.9	6.3	7.6	6.5	6.5	4.7	5.3	4.6	4.9	3.9	4.4	3.5
1909	8.3	6.6	7.7	7.7	6.8	5.2	3.2	3.9	3.8	3.8	3.6	2.9
1910	8.8	7.3	7.2	7.1	7.0	4.0	3.2	3.6	3.8	2.9	3.5	2.5
1911	8.5	7.4	7.1	7.1	6.6	5.1	...	3.8	4.1	4.1	3.9	3.8
1912	9.1	8.2	6.6	7.4	6.4	5.3	4.5	3.9	4.5	3.9	4.1	4.1
1913	8.1	5.9	6.5	6.0	5.9	6.3	4.1	4.2	4.0	4.0	4.4	4.3
1914	8.5	8.4	6.8	7.0	7.0	6.7	4.6	5.1	5.1	4.6	5.2	4.8
Increase in 20 years, per cent	226.9	64.7	65.9	84.2	48.9	157.7	53.6	82.1	104.0	76.9	100.0	92.0

Cost of Production in some of the Principal Countries :—
 This item varies considerably in different countries and even on different plantations in the same country. It depends on (1) the productivity of the soil, (2) climatic conditions, (3) expenditure in cultivation, irrigation and fertilization, (4) transportation facilities, and (5) manufacturing equipment. Table No. 7 below furnishes some of the pertinent figures for Hawaii, Louisiana, Porto Rico and Cuba, gleaned from the United States Government publication above referred to. These are averages for each district for the 1913-14 crop and are expressed in U. S. gold dollar which is normally equivalent to Rs. 3/- . The ton is of 2,000 lbs.

Table No. 7: Average Cost of Production, yields per acre, wages, etc., in Hawaii, Louisiana, Porto Rico & Cuba.

	Hawaii.	Louisiana.	Porto Rico.	Cuba.
	Dollars.	Dollars.	Dollars	Dollars.
Clearing, plowing and planting per acre ...	17.75	...	14.40	4.24
Cultivating per acre ...	30.09	...	13.82	7.85
Irrigation per acre ...	67.91	...	15.76	2.18
Fertilizers and fertilizing per acre ...	42.62	...	8.28	2.43
Harvesting (cutting, loading and transporting) per acre ...	36.53	...	16.05	24.53
Total cost per acre (average for irrigated and unirrigated plantations) ...	176.88	...	68.31	41.23

Sanitation, hospital, etc., per acre	8.69	}	...	22.60	9.41
Insurance, taxes and rent...	16.36				
Depreciation on land and irrigation equipment ...	12.30				
<hr/>					
Total cost including above items per acre ...	214.23	78.10	90.91	50.64	
Tons cane per acre ...	43.92	18.29	20.45	21.32	
Cost per ton of cane at mill	4.66	4.27	4.62	2.37	
Tons cane per ton sugar	8.14	13.96	9.01	8.68	
Cost of cane required to make a ton of sugar	37.95	60.18	41.68	20.56	
Cost of manufacture per ton sugar (including depreciation on manu- facturing machinery) ...	6.64	19.32	10.61	8.36	
<hr/>					
Total cost of production of one ton sugar, f. o. b. factory	44.59	79.50	52.29	28.92	
* Wages of cultivation laborers per day	0.97	0.78	0.69	1.26	
* Wages of cane cutters per day.	1.04	1.22	0.70	1.60	
* Possible yearly earnings:--					
Adult male field hand	302.00	198.00	215.00	378.00	
Adult male cane cutter	243.00	113.00	91.00	249.00	
Adult male cane teamster	269.00	113.00	91.00	207.00	
General mill laborer	224.00	117.00	104.00	190.00	
Centrifugal tender	234.00	106.00	119.00	237.00	
Oiler, mill	248.00	159.00	106.00	219.00	

* Not including labor bonus paid in Hawaii.

POSSIBLE LINES OF DEVELOPMENT IN INDIA.

The establishment of a large central factory is dependent first and foremost on a regular and steady supply of cane. The two main ways of fulfilling this condition are: (1) for the Central Company to own or control large compact blocks of land, and be entirely independent of the small cultivator, and (2) for the Company to enter into contract with the small cultivators who will supply cane to the factory at the prevailing market price or on a profit-sharing basis. In the latter case the Company should own or control a good portion of the acreage needed, so that practical methods of intensive and scientific cultivation could be demonstrated to the small cultivators.

In any event the chief obstacle in the way of sugar development in India seems to be the land question. I venture to suggest the following ways of bringing large tracts under the control of the Company:

(a) By opening up large tracts of virgin forest land. This will be pioneering work beset with many difficulties and hardships. However, one must not lose sight of the fact that all pioneering is arduous. The Americans in Hawaii have gone through immense difficulties. The present day Hawaii, with its good roads, railways, huge irrigation systems and general prosperity for all the people directly or indirectly connected with the industry, is essentially due to those pioneers who introduced the sugar industry some one hundred years ago. The same conditions will hold good in India also. Unless the promoters are imbued with enthusiasm and actuated by business as well as social motives, it is best for them not to enter into this enterprise.

(b) By buying outright from large holders of land. In this case the land is mostly under cultivation and easier to develop in a short time. However, this presents a very dangerous

disadvantage which must not be overlooked. There are invariably very small sub-tenants who are cultivating such lands at present and paying rent to the landlords. In many cases the agreement is only oral. Nevertheless, one must pause before ousting these small tenants who have nothing in this world but their small patches of land. If some equitable arrangements can be made with these sub-tenants, so that they will work in cooperation with the Company, this will prove a very useful source for bringing large tracts under Company's control.

(c) By pooling the lands of several neighbouring landlords who form a Company and turn over their lands for shares in the Company. Preferably they should be active participators in the operations of the Company. Wherever this is possible, it will prove to be the best way of obtaining control over land.

(d) By long-term leases, say, for 30, 50, or 100 years. This is as good as (c) with the only difference in ownership. No one need fear that landlords may not extend the lease after the first period. If sugar cultivation becomes profitable and brings much good to the community, no landlord will be foolish enough to discard a known quantity and begin anew an unknown one.

COOPERATION WITH THE SMALL RYOT:—There now remains the alternatives in which the Company has no control over cultivation. The Ryots' holdings are scattered in small patches all over the territory with demarcations all round. Such a condition militates against deep tillage by means of steam plows or tractors. The Company has to deal with hundreds of ryots, which will give rise to confusion and misunderstanding. In most cases transportation will be slow and wasteful for the factory.

These difficulties can be overcome to a very great extent. If there are capitalists who sincerely wish to improve the lot of the peasantry, this affords an ideal opportunity for rendering

service to them. First of all, the ryots will organize their Panchayats, appoint their representatives who will be better able to deal with the Company and to safeguard their interests. The responsibility for the fulfilment of the contracts on the part of the ryots will rest entirely on the representatives appointed by the Panchayats. The latter can pool the bullock carts and assign them to the particular fields, which are to be cut on a given day under instruction of the Manager of the factory.

The Company on its part will keep one or more agriculturists whose services will be entirely at the disposal of the cultivating ryots. They will advise the ryots on all phases of the agriculture of cane and generally act as intermediaries in order to maintain friendly relations between the Company and the ryots. From time to time they will introduce new and proven varieties of cane and sell seed at cost. The Company will also, after experimentation, secure proper fertilizers and sell them to the ryots who will use them under the direction of the Company's agriculturists. The Company will advance money to the ryots at a reasonable interest against the ryots' cane to be delivered as, and when, the factory needs,

This method is working in certain parts of Hawaii, Porto Rico and the Philippine Islands. Some centrals base the price of cane delivered on its sugar content according to a sliding scale, while others adopt a profit-sharing basis. By far the most equitable basis is the profit-sharing plan. It is an inducement to the small cultivator to plant as much as possible of his land with cane, to produce the maximum possible crop with the facilities at hand and to deliver the cane as, and when, the central requires. All these factors are as much to the benefit of the cultivator as to that of the central owner.

In Porto Rica and the Philippine Islands all the new centrals, that are being built now-a-days, contract with the

cultivator to pay him half of the sugar manufactured from his cane. It would undoubtedly be the best impetus to the Indian sugar industry, benefit the investor as well as the cultivating ryot equally, eliminate all suspicion of profiteering on the part of the capitalists at the expense of the ryot, and establish harmonious cooperation between both parties. But the ryot must meet the fundamental requirements by living up to his contract to grow cane on a certain number of acres of his holding. Without this assurance no capitalist can sink his capital in a factory which runs the risk of remaining idle at times.

COST OF PRODUCTION IN INDIA AND ESTIMATED PROFITS :—
 There are hardly any reliable data available in India, which renders it difficult to make any estimate. In the United Provinces and in Bihar the cost of raising an acre of cane in 1915 was between Rs. 15/- and Rs. 20/-. * This is stated to include rent and seed. There is no irrigation nor any manuring. Perhaps the labor of the ryot is not included. Others estimate the cost at about Rs. 100/-. A good normal crop in that locality is said to be 12 tons of cane per acre. It is also well-known that the cane is very poor in quality.

In the North West Frontier Provinces it is estimated by expert agriculturist that the cost per acre including rent is Rs. 150/-. The land yields 25 tons of cane per acre.

In parts of Madras Presidency the average cost runs from Rs. 250/- to Rs. 300/- per acre, and the yield is about 30 tons.

In the Deccan with heavy manuring and ample irrigation the cost per acre is between Rs. 300/- and Rs. 400/. In exceptional cases it is Rs. 600/-. But there are evidences which point to the use of more water and fertilizer than are needed. In fact there are fields which are becoming water-logged, because the

* Evidence by J. Henry, Cane Manager, Darbhanga Sugar Co., Ltd., before the Indian Industrial Commission, 1916-17. Vol. I, pp. 382-385.

ryot is required to keep all of the water in his field. With proper drainage these fields should produce more than at present. The average yield in the Deccan is between 30 and 40 tons.

From Table No. 7 we see that the cost per acre in Hawaii is roughly Rs. 650/- of which labor takes Rs. 325/-. Average labor is paid about Rs. 3/- a day, while in India the present rate for agricultural labor is nowhere more than eight annas, or one-sixth of that in Hawaii. The cost of water, as a rule, is cheaper in India. Therefore, taking these facts into consideration, Rs. 400/- an acre should be a fair average for India. The average yield per acre will easily be 30 tons of cane. This is a conservative estimate for the beginning of the enterprise, and will no doubt be bettered in later years.

COST OF MANUFACTURE OF WHITE GRANULATED SUGARS:—It is generally estimated in this country that ten tons of cane will give a ton of sugar in modern well-equipped factory. Still better results will be obtained depending in the sugar content of the cane and on the purity of the juice. But, for the purpose of an estimate it is safe to take this conservative ratio and figure the cost of manufacture of white sugar. Table No. 8 below gives the estimated cost of manufacture in India.

Table No. 8: Estimated Cost of Manufacture per ton of white sugar in India, excluding depreciation on manufacturing machinery :

Cost of 10 tons of cane at the factory	Rs. 133/-
Cost of manufacture including administration, but excluding depreciation	„ 20/-
Cost of bags	„ 10/-
<hr/>	
Total cost per ton white sugar, f. o. b. factory, excluding depreciation	Rs. 163/-

DEPRECIATION ON MANUFACTURING MACHINERY :—In estimating cost of production in India this is by far the most important item. In almost all the other countries the harvesting season extends over from six to ten months, while in India the maximum period is only four months. In Hawaii a factory grinding one thousand tons of cane per day, based on ten tons cane to one ton sugar, will produce 20,000 tons sugar per year during 200 working days. While in India a similar factory will produce not more than 12,000 tons of sugar per year during 120 working days. Therefore, depreciation per ton of sugar will be higher in India than in Hawaii.

Secondly, depreciation per ton of sugar will also depend on the capacity of the factory. The larger the factory the less money invested in machinery per ton of sugar to be produced. Therefore, the larger the size of the factory the less depreciation is to be charged against a ton of sugar produced. This will be seen from Table No.9 below :

Table No. 9:—Depreciation per ton sugar in factories of various sizes.

Capacity in tons cane per day	100	200	300	500	1,000	1,500
Estimated cost of machinery in lakhs of rupees	5	8	11	17	30	40
Depreciation at 5%	Rs. 250,000.	40,000.	55,000.	85,000.	1,50,000.	2,00,000.
Tons sugar to be produced	1,200	2,400	3,600	6,000	12,000	18,000
Depreciation per ton sugar Rs.	21	17	15	14	13	11

TOTAL COST, F. O. B. FACTORY:—Table No. 10 takes depreciation into consideration and shows the total cost per ton of sugar delivered in the factory warehouse.

Table No. 10: Total cost per ton of sugar, f. o. b. factory in India, including depreciation :

Capacity in tons cane per day	100	200	300	500	1000	1500
Cost per ton sugar Rs-	163	163	163	163	163	163
Depreciation per ton Rs.	21	17	15	14	13	11
Total cost, f. o. b. factory	184	180	178	177	176	174

FOREIGN COMPETITION :—Java is the principal competitor in this market and in recent years has supplied most of the foreign sugar consumed in India. According to Dr. H. C. Prinsen Geerligs' calculation based on a large number of data recently collected the net cost of white sugar at the shipping points in Java, including taxes, was £. 22-1s.-3d. per ton in 1920*. To this price are to be added freight and insurance to Indian points and 15% ad valorem duty in India. Without taking freight and insurance into consideration and figuring the exchange at one shilling four pence to the rupee the cost of Java sugar in Indian points will be as in Table 11.

Table No. 11: Cost of Java sugar in Indian ports :

	Two shillings to the rupee. Rs.	1s. 4d. to the rupee. Rs.
Cost per ton in Java shipping points.	220/-	330/-
Ad valorem duty @ 15%	33/-	50/-
Cost per ton excluding freight and insurance	253/-	380/-

As will be seen from Table No. 10, the highest cost of Indian made sugar per ton is Rs. 184/- which compares very favorably for the Indian manufacturer. It leaves a margin of Rs. 69/- in favour of the country-made product.

* The International Sugar Journal, London, 1921, pp. 78, 79.

Prior to the war German and Austrian sugar had sold as low as Rs. 200/- a ton. Conditions in Europe indicate that Germany will have very little for export for many years to come. In case there is any available for export, it will find its way to the London market. Austrian sugar industry is entirely crippled and Austria has to import almost all her needs now. Therefore, competition from these two countries is out of the question for many years to come. Considering the deficit in the world's production which is bound to exist for several years it is very doubtful if sugar will come down below Rs. 400/- a ton. In my judgment there never was such an opportune movement as the present time to introduce large-scale production of sugar in India. As I have shown above, Java sugar has no chance for competing against Indian sugar in the Indian market.

ESTIMATED PROFITS:—Profit per ton of sugar will now depend on its selling price. Table No. 12 shows the profit per ton produced in factories of different sizes, and at different selling prices. I have taken the two extreme prices, Rs 200/- which had prevailed before the war and Rs 600/- which is the prevailing price at the present time.

Table No. 12: Profit per ton sugar :—

	Rs.	Rs.	Rs.	Rs.	Rs.
Selling price per ton	200	300	400	500	600
Cost per ton in 100 ton factory	184	184	184	184	184
Profit „ „ „ „ „	16	116	216	316	416
Cost „ „ „ 200 „ „	180	180	180	180	180
Profit „ „ „ „ „	20	120	220	320	420
Cost „ „ „ 300 „ „	178	178	178	178	178
Profit „ „ „ „ „	22	122	222	322	422
Cost „ „ „ 500 „ „	177	177	177	177	177
Profit „ „ „ „ „	23	123	223	323	423
Cost „ „ „ 1000 „ „	176	176	176	176	176
Profit „ „ „ „ „	24	124	224	324	424
Cost „ „ „ 1500 „ „	174	174	174	174	174
Profit „ „ „ „ „	26	126	226	326	426

CAPITAL INVESTMENT AND NET RETURN:—Capital outlay necessary for sugar plantations is dependent on various circumstances. The question of land has to be left entirely out of consideration, because it may be bought at different prices, or leased at different rentals, or the cane may be bought from ryots. Similarly, the capital expenditure for irrigation projects will be different propositions. Water may be obtained by gravity or may be lifted to different heights. Therefore, a general estimate of the required capital includes only (1) the approximate cost of machinery landed in India, (2) the total cost of production both agricultural and manufacturing, and (3) an ample fund for unforeseen charges. Table No. 13 gives capital investment, net return, etc., under varying conditions.

From the above table it is seen that there is a very good margin of profit even in the smallest-sized factory when sugar is selling at Rs 300/- per ton. As stated before, the chances are that sugar will not sell in this market below Rs. 400/- per ton. It must also be remembered that the value of the molasses has not been taken into account in the calculation of profits. The molasses will either be sold or converted into alcohol fuel and fertilizers on the plantation. Even Java molasses and alcohol are sold in the Indian market at a profit.

Economic Size of the Factory:—As stated previously, other countries have learnt from experience that the larger the factory, the better economies can be effected and the less the cost of production. All the modern factories, that are being built in any new territory, have a minimum crushing capacity of 1,000 tons of cane in 24 hours. The larger plants will be able to withstand bad times better than the smaller ones. Therefore, taking everything into consideration, the objective in India should be 1,000 ton plants.

Benefits to be derived by the Country:—The introduction of the sugar industry on a large scale will first of all give an

Table No. 13:—Acreeage necessary, sugar produced, capital investment, net return, etc., under varying conditions.

	100	200	300	500	1,000	1,500
Capacity in tons cane per day	100	200	300	500	1,000	1,500
Total acreage to be commanded based on 3-year rotation	1,200	2,400	3,600	60,00	12,000	18,000
Annual acreage under cane to be harvested	400	800	1,200	2,000	4,000	6,000
Tons of cane to be crushed per year	12,000	24,000	36,000	60,000	1,20,000	1,80,000
Tons of sugar to be produced	1,200	2,400	3,600	6,000	12,000	18,000
Tons of molasses to be produced	360	720	1,080	18,00	3,600	5,400
	Rs.	Rs.	Rs.	Rs.	Rs.	Rs.
Capital investment	10,00,000	15,00,000	20,00,000	30,00,000	50,00,000	70,00,000
Capital investment per ton sugar	833	625	556	500	417	389
Net profit from the sale of sugar alone @ Rs. 200 per ton	19,200	48,000	79,200	1,38,000	2,88,000	4,68,000
Net return on investment	2%	3%	4%	5%	6%	7%
Net profit from the sale of sugar alone @ Rs. 300 per ton	1,39,200	2,88,000	4,39,200	7,38,000	14,88,000	22,68,000
Net return on investment	14%	19%	22%	25%	30%	32%
Net profit from the sale of sugar alone @ Rs. 400 per ton	2,59,200	5,28,000	7,99,200	13,38,000	26,88,000	40,68,000
Net return on investment	26%	35%	40%	45%	54%	58%
Net profit from the sale of sugar alone @ Rs. 500 per ton	3,79,200	7,68,000	11,59,200	19,38,000	38,88,000	58,68,000
Net return on investment	38%	51%	58%	65%	78%	84%
Net profit from the sale of sugar alone @ Rs. 600 per ton	4,99,200	10,08,000	15,19,300	25,38,000	50,88,000	76,68,000
Net return on investment	50%	67%	76%	85%	102%	110%

impetus to the improvement of agriculture in general. Wherever a plantation is established, the results obtained from improved methods of cane cultivation cannot but have their effect on other crops grown in the vicinity. The knowledge that the plantation will bring to the community will benefit all alike.

The plantation will take the initiative in improving roads. It will introduce sanitation which will benefit its employees as well as the public. It will establish schools for the children of its employees where other children also will receive their education.

The Sugar industry is purely an agricultural industry. It will be to the best interests of the industry to keep the people on the land. Hundreds of thousands of people will be employed who will live far from the cities out in the open, breathe fresh air day and night and keep their health intact, which is not the case with city industries. It will be a great comfort to those, who are constantly crying against the introduction of the industrial system, to know that the sugar industry will perpetuate the existing agricultural nature of our vast population with the added features of improved agriculture for the ryot, of better income for more of the agriculture laborers than at present, and of better general prosperity. It will accomplish all this without bringing in the evils of modern city life.

Sugar will bring with it many subsidiary industries which will be of immense benefit to the country. Among them the most important are (1) fertilizers, (2) farm implements, (3) cattle and dairy, (4) raising of horses, (5) manufacture of alcohol and recovery of potash and nitrogen fertilizers from molasses, (6) sugar-manufacturing machinery, (7) lime and cement, and (8) a brisk import trade in chemicals and laboratory supplies.

Conclusion:— We have seen that the manufacture of sugar, one of the oldest industries of India, is in a deplorable condition.

We are losing crores of rupees every year by following very primitive methods of agriculture and manufacture, while the rest of the world, after borrowing the fundamental knowledge from us, has made marvelous progress in the industry. _

We have also seen the present condition of the world's sugar production with a deficit that will remain for some years to come. The profits to be derived are substantial. The benefits that the industry will confer on the country are varied and large. The sugar industry will in no way work against the agricultural nature of the Indian population. It will rather improve our rural conditions and rural economy. Therefore, there is no question about the advisability of introducing this industry into India. Added to all these advantages, when we remember the existing shortage in the world's crop, I am led to the conclusion that this is the most opportune time to launch into this enterprise.

**Note on Sugarcane Cultivation for the use of
ryots in North Arcot, South Arcot and
Chittoor districts.**

How the ryots cultivate sugarcane.

In cultivating sugarcane, ryots in different villages follow different methods. Before giving advice as to the best method to be followed, it will be well to describe the methods now used by the ryots. The land selected is usually a wet land in the ayacut of a tank or channel which gives a good supply of water, but in Nellikuppam ryots have recently begun to grow sugarcane in dry lands irrigated by a well. In some villages in preparing the land for sugarcane cultivation the soil is ploughed wet and the sugarcane sets are planted in lines from 1 to $1\frac{1}{2}$ feet apart. In other villages, the ryots plough the soil dry after the harvest of paddy. When the soil has been thoroughly ploughed the field is divided into small ridges and furrows at a distance of $1\frac{1}{2}$ feet apart. The ridges are first made with a country plough and later are shaped with mamuties, and the sugarcane sets are then planted in the furrows close together. In some villages, beds of convenient size are formed and in each bed half a dozen short furrows are made and the sets are planted in the furrows. In other villages the land is broken up with a crowbar and large lumps of earth are heaped into rough ridges and furrows and sets are planted in the furrows thus made. In other villages, trenches of 1 foot wide and 1 foot deep are dug at distances of 3 or $3\frac{1}{2}$ feet from the centre of one trench to the another. The sets are then planted in the trenches so close that they almost touch each other.

For manuring, some ryots pen sheep and apply cattle manure to their fields. In addition they put on it large quantities of pungam leaves and flowers when the canes are beginning to grow. They also soak pungam-cake and cattle-dung in a pit for about a week. They then let water flow through the pit to the sugarcane crop. In other villages the ryots give oil-cakes (groundnut, castor or pungam) both when they plant the sets and subsequently from time to time till the fifth month.

For sugarcane sets, some ryots use only the top of the shoot, and others cut the whole cane into sets and use all of it. Some ryots plant about 9,000 sets per acre, while others plant as many as 30,000. Where the irrigation is uncertain, the ryots use the cane known as 'Nanal' which takes about 8 to 9 months to grow ripe. In other places the cane most grown is the 'Namam' which is also called Rasthali, Namalu, Dasari or Izar. Near Nellikuppam, the new varieties of cane introduced by the Agricultural Department, such as Mauritius cane, Java cane, Barbados cane and Fiji cane are grown instead of the local canes, as they are found more profitable.

Some ryots support canes by bamboos, wrapping them at random, and other ryots do not trouble themselves to do this.

Recommendations.

As the soil and irrigation facilities are different in different places it is not possible to recommend a single method of cultivation as suitable for all lands. But those who wish to make a profit by growing sugarcane should remember the following general principles.

How to choose the land.

The most important thing is to select a suitable land. Sugarcane requires plenty of irrigation. It also requires rich soil or much manure. For this reason ryots are apt to choose the best wet land or heavy loamy soil for growing the crop. When they do so, they do not consider sufficiently whether the land can be properly drained. From the best wet lands and heavy soils water cannot be easily drained off. On the other hand in light sandy soils from which water can easily be drained, the cost of manuring will be heavy, and the crops may suffer soon from lack of water. However, we must remember that though sugarcane requires plenty of irrigation, it cannot thrive in badly drained soils. If immediately after we have planted the sugarcane sets, a badly drained soil gets soaked owing to irrigation or heavy rainfall, the sets will rot without sprouting. We often see that in badly drained heavy soils the leaves of the sugarcane turn yellow and sickly. This is because the air cannot reach the roots of the sugarcane. If the roots were to go down deep into the cold wet layers of the soil, the air and the warmth could not reach them. For this reason the roots will spread along the surface without entering deep into the soil. When the roots do not enter deep, the canes, when they grow up, are easily blown down by the wind in the monsoon time. The fallen canes contain very little sugar. If these fallen canes are crushed with other canes, all the jaggery will be spoiled. There will be a great loss to the cultivator. Further, canes grown in heavy wet, ill-drained soils are apt to be attacked by diseases like red-rot. Hence in selecting the land for sugarcane we must remember three things--(1) The land must be fertile. (2) It must also be easily irrigated. (3) Lastly, it must be possible to drain the water away from it easily.

Drainage.

Even if the soil can easily be drained, it is necessary to take precautions to ensure that neither rain water nor irrigation water should be allowed to rise above the surface of the soil. If the soil is stiff and heavy, deep trenches must be dug between the canes, so that water may quickly be carried away. For this reason it will be necessary to plant sugarcane in rows. Though the ryots do this in many villages, yet they often fail to make arrangement to carry away the drainage water. In many villages the ryots plant the rows so close together that it is not possible to dig drains between them to take away the water. The rows should therefore be 3 or 4 feet apart from centre to centre instead of 1 foot to 1½ feet. In most villages ryots use the channels dug for irrigation to drain away the water. As the channels are shallow the irrigation water spreads over the surface especially during the rains and prevents the canes from growing properly. Care should be taken to dig the drains so deep that the irrigation water let into

them will not come within a foot of the top of the ridge after the crop has been earthed up. If this is done, there will be no damage to the crop.

Manure.

If suitable manure is given in proper quantities, this will be beneficial to the sugarcane. If we plough green manure crops into the soil, this will not only provide food for the sugarcane but it will also improve the soil. If green manure has been ploughed in, water will drain through the soil more easily and the roots of the sugarcane also will penetrate into the soil more readily. When the land is being prepared for cultivation, many ryots pen sheep or apply cattle manure. If nightsoil manure is put on the land, this also will be useful. It is certain that the land must be manured before sets are planted, so that they may grow up well. But we ought not to put all the manure which the crop requires into the soil in one lump at the start. Instead of this, it is better to give manure little by little at intervals as the crop grows. We should give manure for the second time $1\frac{1}{2}$ months or 2 months after sets are planted.

We should manure the crop for the third time in the third or fourth month, just before we earth up canes for the last time. About 3 or $3\frac{1}{2}$ candies of oil-cake (castor, groundnut or pungam) or fish manure will usually be sufficient for one acre. If green leaves like kolinji, pungam and indigo are available, they can be used before we earth up the plants. The ryots of Chittoor and South Arcot do this.

What sets to use.

We do not sow seeds of sugarcane; instead, we plant the cuttings taken from old sugarcane plants. The top portion of the cane sprouts best. Therefore we should use only the top portion for sets. In selecting sets for planting, we should take only the healthy plants which are not stained with a red colour. The best thing to do is to select healthy plant before sugarcane are cut and then to cut these plants in the fields for sets.

What varieties of cane to choose.

In choosing the variety of cane to be planted, we should remember that it is not safe to plant only one single variety over a large area. If we do this, it will not be possible to crush all the canes as soon as they become ripe. If canes are left in the field after they become ripe, they lose part of their juice and there will be a loss to the ryots. Therefore we should select different varieties of sugarcane for different fields. Then the canes in some fields will ripen early, while the canes in other fields will ripen later. It will then be possible to crush all the canes as soon as they become ripe, and there will be no loss. We find that the new canes Fiji B and B-208 stand a little longer than other varieties without becoming spoiled. The canes called B-1529 and J-247 ripen a month earlier than others. Red Mauritius cane and the cane called B-147 both get ripe a little later than B-1529 and J-247, but earlier than the canes called Fiji B and B-208.

How to plant these sets.

It has already been said that while some ryots plant only 9,000 sets per acre, others plant as many as 30,000. In this matter the ryots of Chittoor and North Arcot districts act unwisely. If too many sets are planted, the plants have no sufficient room; therefore they will not send out many shoots. At the same time about 20 per cent of the sets die soon after sprouting. Besides this the canes do not grow uniformly either in thickness or in height. Thus there is a great loss to the ryots who plant too many sets for an acre. In Chittoor district 1,000 sets of one cubit long cost as much as 80 lb. of jaggery at harvest time. If we plant in rows 3 feet apart there will be a saving of Rs. 70 an acre in the number of sets used. Some ryots near Madanapalle have adopted this practice and are now using only 10,000 sets an acre, while formerly they used 30,000 sets. They call the new planting system 'circar totta'. Remember therefore that you should plant your canes in rows at a distance of 3 feet apart and that you should not use more than 10,000 sets in an acre.

How to cultivate after planting.

We must hoe the ground repeatedly so as to keep the field clean of weeds and to make the surface soil loose. If this is done, young roots will spread easily and take up nourishment and the canes will grow large. Whenever we irrigate the land, we must take care that the water does not rise above the level of the furrows from which water flows. In Chittoor district the ryots twist the lower leaves of the sugarcane as soon as they begin to become old and tie them round the stem of the cane as the canes grow. This is done partly to prevent the jackals from biting the canes and partly to make the cane grow taller. In some places they tie the canes to bamboos as a support. This is necessary when the canes are planted in shallow furrows or when the soil is not sufficiently drained. In such places the roots of the cane do not go down deep. It is therefore necessary to support the canes. But to wrap the leaves round the cane or to support the cane with bamboos is very costly. To save this expense, in Nellikuppam the ryots plant improved varieties of cane which are so hard that the jackals cannot bite them. Then it is no longer necessary to wrap the leaves round the cane. Further near Nellikuppam they plough the land deep, they drain the land thoroughly and they plant the canes far apart. The result is that the roots of the canes go deep into the soil and the plants send out many shoots. Thus they support each other without the help of bamboos.

The advantage in growing the new varieties of cane.

The new varieties called B-208 and Fiji B are short and stout and produce plenty of side shoots. The Java canes are stronger canes and are able to stand against the wind better. These varieties give a better yield of jaggery than the local canes Nanal and Namam; and they are less often attacked by disease. If the ryot grow these

varieties, he will get better yield ; at the same time the cost of cultivation will be less, as bamboos to support canes will not be necessary.

How to cut the cane.

It is well to irrigate the field freely before cutting the cane for crushing, as this improves the quality of the jaggery. If this is done, the quality of the jaggery will be improved. Ryots now cut the cane 4 or 5 inches from the ground, leaving the stump in the ground ; but the stump of the cane contains the largest proportion of juice. Hence this practice is wasteful. To prevent this waste we should cut the cane at the surface of the soil with a heavy knife or mamuty.

How to boil the jaggery.

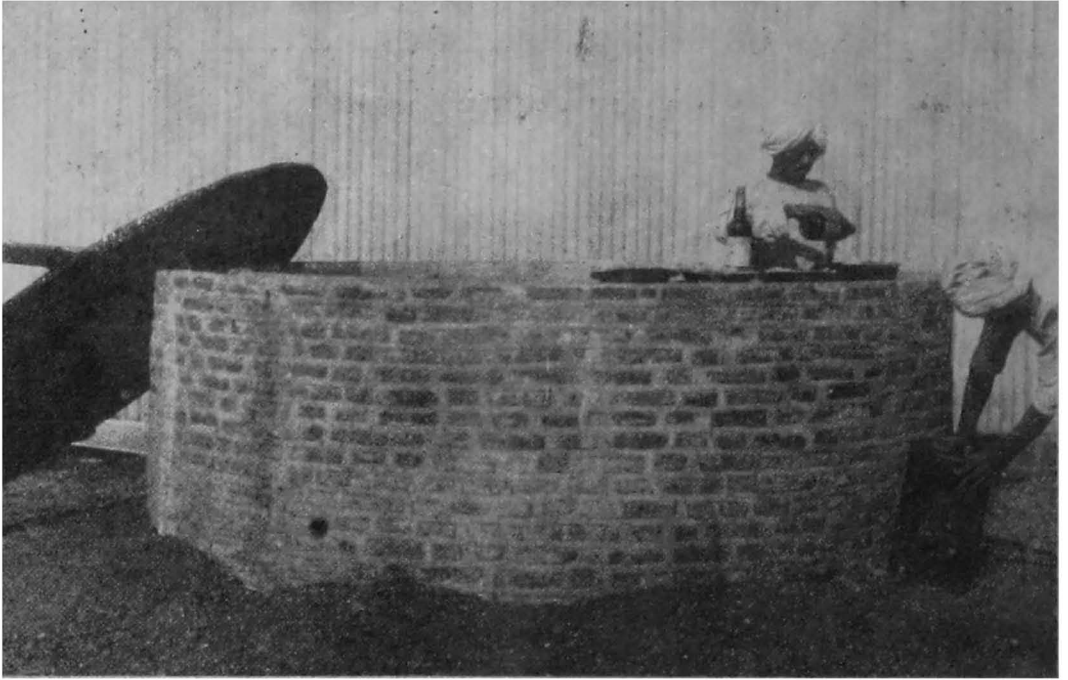
The best methods of preparing jaggery are described in the Agricultural Department Leaflet No. 22. A copy of this leaflet can be obtained by writing to the Publicity Officer, Victoria Buildings, Commander-in-Chief Road, Egmore, Madras. In Chittoor and North Arcot districts the ryots use a furnace similar to the one recommended in that leaflet. Nevertheless, they still find it necessary to use a great quantity of fuel. About 10 tons of fuel in addition to the refuse of the cane is used for manufacturing the jaggery that is obtained from one acre. This is because the ryots use pans made of thick iron sheets. The pan used for manufacturing 35 lb. of jaggery weighs nearly 300 or 400 lb. If the ryots use pans made of thinner sheets, they can save 6 or 7 tons of fuel in the manufacture of jaggery for each acre.

J. CHELVARANGA RAJU,

Deputy Director, IV Circle.

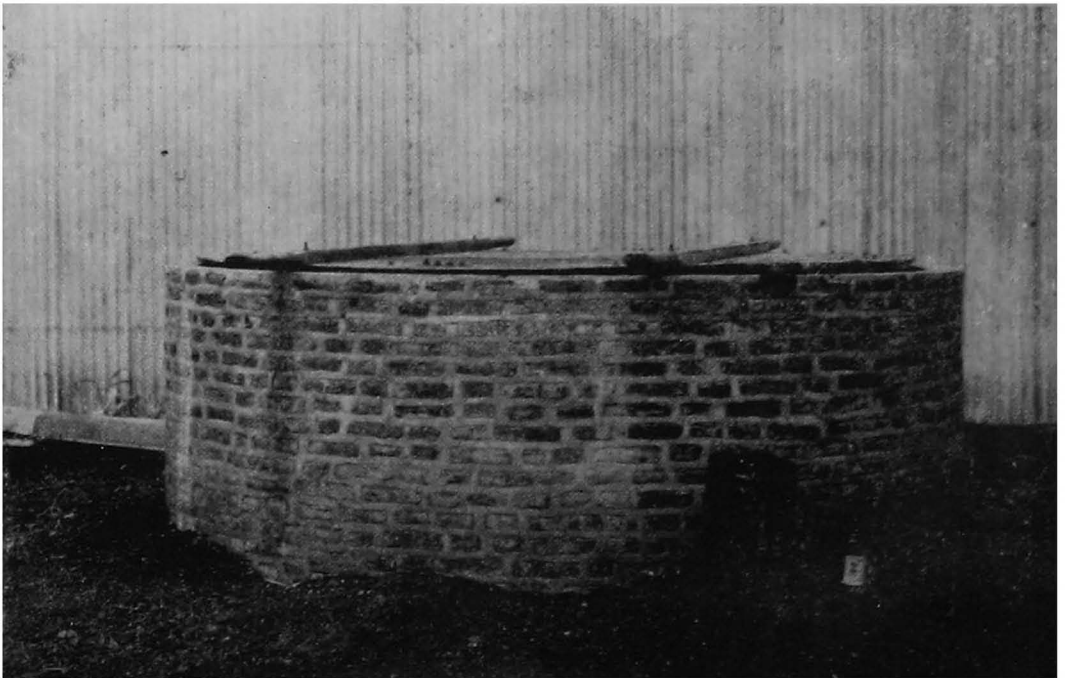
[*N.B.*—Please give this to a landholder who cultivates sugarcane. If you can distribute more copies please write to the Publicity Bureau, Victoria Buildings, Commander-in-Chief Road, Madras.]

PLATE I.
(*Frontispiece.*)



Fumigation Chamber as used in the Khed Potato Tract. (1) Open.

PLATE I.



Fumigation Chamber as used in the Khed Potato Tract. (2) Closed.

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C. I. A.

INVESTIGATIONS ON POTATO CULTIVATION IN WESTERN INDIA.

The cultivation of potatoes in Western India does not occupy altogether a very large area, but its possibilities are enormous, and, this being the case we have undertaken the study of this crop, with a view to its improvement and extension. The present bulletin consists, in fact, of a description, by personal survey, of the conditions in several of the areas as they are at present, and of the difficulties and deficiencies revealed. Beyond this we have described what has been done in time past in the way of experiment to remove those deficiencies and also our own experiments since 1916 in studying these difficulties and in devising and popularising methods for meeting them.

We have actually studied the potato and its cultivation in three or four centres in the Deccan and Karnatak and we must first indicate the conditions in each of these areas.

I.—POTATOES IN THE KHED TALUKA OF THE POONA DISTRICT.

BY S. D. NAGPURKAR, B.Ag.

Of all the areas of potato cultivation in the Bombay Presidency that which occurs in the Khed taluka of the Poona district is considerably the most important. The area under the crop has in the past twenty-five years varied from little more than 3,000 acres (3,346) to a maximum over 8,000 acres (8,369) in any one year. The variation in acreage is shown in the following table, which also indicates the proportion of the potatoes cultivated in this taluka to the whole cultivation of this crop in the Poona district. The famine of 1918-19, which was especially severe in the potato tracts where such a visitation had previously been almost unknown, combined with the impossibility of importing fresh seed suitable to this tract from Italy owing to war conditions, has almost caused the collapse of the industry in 1919-20. The area

has, in fact, nearly sunk to nothing. This collapse is, however, temporary, and there is no doubt that the industry will recover rapidly if seed is available :—

Year.	Area under Potatoes.		Proportion in the Khed Taluka. Per cent.
	Khed Taluka.	Poona District.	
1890-91	4,429	6,463	68·3
1891-92	5,480	7,771	70·5
1892-93	5,263	6,781	77·6
1893-94	4,993	7,563	66·0
1894-95	5,273	7,173	73·5
1895-96	7,160	9,245	77·4
1896-97	4,906	5,557	88·3
1897-98	5,349	6,313	84·7
1898-99	6,159	7,141	86·2
1899-1900	4,094	4,445	92·1
1900-01	4,133	4,851	85·2
1901-02	6,591	7,594	86·8
1902-03	7,646	8,724	87·6
1903-04	8,369	9,698	86·3
1904-05	3,424	3,789	90·4
1905-06	3,346	3,543	94·4
1906-07	3,495	4,032	86·7
1907-08	5,535	6,385	86·7
1908-09	4,980	5,626	90·6
1909-10	5,936	6,905	86·0
1910-11	5,654	7,389	76·5
1911-12	5,504	6,238	88·2
1912-13	4,967	5,442	91·3
1913-14	5,153	6,026	85·5
1914-15	5,133	6,345	80·9
1915-16	6,909	5,889	85·2
1916-17	7,745	5,917	76·4
1917-18	4,916	4,586	93·3
1918-19	2,614	2,344	90·0

These figures show that, if we exclude 1918-19 and 1919-20, while there have been considerable variations in the annual area, yet there has been little permanent alteration in the extent of the potato cultivation. This is better shown by the following figures giving the average area in the Khed taluka for each five years since 1890 :—

	Acres.
1890-1894 ..	5,087
1891-1895 ..	5,633
1892-1896 ..	5,519
1893-1897 ..	5,536
1894-1898 ..	5,769
1895-1899 ..	5,533
1896-1900 ..	4,908
1897-1901 ..	5,265
1898-1902 ..	5,724
1899-1903 ..	6,166
1900-1904 ..	6,032
1901-1905 ..	5,875
1902-1906 ..	5,256
1903-1907 ..	4,833
1904-1908 ..	4,156
1905-1909 ..	4,658
1906-1910 ..	5,120
1907-1911 ..	5,521
1908-1912 ..	5,408
1909-1913 ..	5,442
1910-1914 ..	5,280
1911 ..	5,504
1912 ..	4,967
1913 ..	5,753
1914 ..	5,133

There was a fall in area in the famine period from 1896 to 1900, and again a larger fall in the years following 1903, which seems probably due to a series of years of small

rainfall,—but otherwise, the normal area in the taluka seems to be between five and six thousand acres rising a little higher when conditions are favourable and falling a little when rain is short, good seed is difficult to get, or when there is some other special temporary factor influencing the cultivation.

The area too forms a fairly constant proportion of that in the Poona district, at any rate since 1895,—as the following average figures show :—

Years.	Proportion of the total area in the Poona District.	
	Per cent.	
1890-1894	..	71·2
1895-1899	..	85·7
1900-1904	..	87·2
1905-1909	..	88·8
1910-1914	..	84·4

How long the growth of the potato has existed as an intensive culture in the Khed taluka, we cannot tell. Inquiries of the oldest people in the villages led to no information,—but potatoes were grown near Junnar as far back as 1841.

Soon after the Agricultural Department was established, one of the matters which came to its notice was the existence of a serious potato disease which was doing great harm in the Khed taluka, and for several years the annual reports of the Agricultural Department * contained a good deal of reference to this disease, and two bulletins † were also issued on the subject, the second one (in 1893) describing the conclusions which were reached. This disease, termed ' *bangdi* ,' is still common, and does, still, a very great deal of damage to the potato crop of the taluka. It was dealt with by using Italian seed, which was found to be almost if not quite free from the disease, and *perhaps* to be resistant to it.

* Annual Reports of the Director of Agriculture, 1890-91, 1891-92, 1892-93, 1893-94, 1894-95, 1895-96.

† Agricultural Department, Bombay, Bulletins 13 (1892), 16 (1893), Agricultural Ledger No. 4 of 1905.

Since the time when this disease was so much discussed little reference to this important agricultural industry in Khed exists in the reports, papers, or bulletins issued by the Agricultural Department.

The cultivation of potatoes as carried out in the Khed taluka varies in method to a considerable extent. There are two crops in the year. In the older bulletins it is stated that the *kharif* crop is only taken in order to provide seed for the larger *rabi* crop. This is the case in some villages, but not by any means in all, and in a number of villages the *kharif* crop is more extensive. In Chakan, for example, the *kharif* crop is very small, almost entirely for seed purposes; in Peth and the surrounding villages, on the other hand, the *kharif* crop is much larger in proportion. The relative acreage of the two crops in five recent years in the taluka is shown in the following figures which give the area in villages only which have grown more than one hundred acres in any year :—

		<i>Kharif.</i>	<i>Rabi.</i>	<i>Rabi.</i>
		Acres.	Acres.	Percentage of Total.
1910-1911	..	1,209	2,441	67
1911-1912	..	1,215	2,439	67
1912-1913	..	1,020	2,042	67
1913-1914	..	1,412	2,304	62
1914-1915	..	1,453	2,914	67

We shall first describe the method of cultivation in vogue for the *rabi* or cold weather crop in several typical centres, and then indicate the difference in the practice with the *kharif* or rains crop. At Chakan, where perhaps the greatest care is taken, the land on which it is intended to plant potatoes is shown with *bajri* which is harvested in September. Immediately after this, as soon as the condition of the soil allows it, the land is ploughed with the usual wooden plough of the Poona type, with three to four pairs of bullocks. After a week a second cross ploughing is carried out, the

clods are then broken with a harrow, and the field made level. After this twelve to twenty cartloads, or say 10,000 to 16,000 lbs. per acre of usual village manure are carted to the field, and made into small heaps at regular intervals. Then follows the making of furrows with a small plough (*nangari*), this being generally done in the beginning of November, but the exact time depends on the condition of the land. The furrows are six inches apart.

The seed is now immediately sown. This is generally of a round white Italian variety which has proved itself an excellent yielder and fairly resistant to the *bangdi* disease. It has been in the past especially imported from Italy, and most cultivators have tried to obtain new seed say at least once in four years. If not obtained it seems to be the usual custom to try and get seed from another village, especially a village to the west, in the *Mawal* tract, if the seed is needed for the *rabi* crop. A good deal of land is, however, planted with seed bought simply for the purpose from the local or the Poona bazar. In Chakan the seed employed by the ordinary cultivators is mixed to the extent of about two per cent. with a long red variety stated to be from Mahableshwar, but which we now know occurs in the Italian seed as imported.

The universal seed rate given seems to be four pallas of 280 pounds, or 1,120 pounds per acre. The seed is always cut into pieces according to the size of the potato. The cut sets are examined for ring disease (*bangdi*) and if it is seen to any considerable extent in the sets, the whole is rejected. Little notice is, as usual, taken of a small amount of ring disease in the seed. The seed is sown by hand, the bottom of the furrow being covered with manure before the sets are put in or else the manure is scattered over the planted sets. The sets are placed nine inches apart and thus the maximum number per acre is 80,000. After sowing, *wafas* (beds) are made, each including five *saries* (rows). Then the sets are watered with irrigation water. The sowing,

wafa making and watering are done on the same day, and watering is repeated after fifteen days. This watering is termed *ambawani*. Another watering after a further twelve days is termed *chimbawani*. If the seed has been good by this time germination will have taken place and the shoots are visible on the surface, and weeding is therefore possible and is done.

Following this the crop is earthed up,—an operation carried out in Chakan but not in most of the other villages of the tract. This operation is termed *khandani* or *bharani*. It is done by hand labour, the ordinary *kudal* or *hoe* being used for the purpose. Thereafter regular watering only is needed every tenth or twelfth day and occasional weeding.

Harvesting is usually carried on when the plants are yellow and show signs of drying. The best cultivators, however, prefer to harvest at rather earlier than this stage. Little difference is made here as to the time of harvesting for seed and for market, except that the first harvested are generally kept for seed. The digging up of the tubers is done by the small *nangari* plough previously referred to.

Harvesting usually occurs $3\frac{1}{2}$ months after sowing. After the potatoes turned up by the first operation with the *nangari* have been collected, the land is worked again with the same implement, and another lot is turned up and collected. The operation is repeated several times until no more tubers are obtained. Only those turned up in the first ploughing are taken away and stored for seed: the remainder are at once sent away to market for sale. We will deal separately with the methods of storage used by the people.

The actual outturn which the cultivators expect to get is from eight to twelve times the amount of seed potatoes employed. This is, therefore, from 8,960 pounds to 13,440 pounds per acre or say 4 tons to 6 tons per acre. Occasional records there are of crops having gone up to fourteen to sixteen times the seed used or 8 to 10 tons per acre, but

these are rare and until recently were hardly believed among the people themselves.

Apart from the difficulties of seed and disease, with which we will deal separately, the gradual reduction in the quantity of manure available is one of the serious matters on which stress is laid by the people. The reduction in the available fodder by the absorption of all surrounding grass areas for the commissariat department has caused a reduction in the number of cattle and hence in manure. So far artificial manures have not been used in Chakan, but there is little doubt that if introduced after due trial the potato cultivators would be prepared to use them, and would purchase them in large quantities.

Such are the methods and difficulties which prevail at Chakan. The methods in vogue at other centres are on the whole similar, but there are differences which are worthy of record.

At Khed the cultivation is almost entirely carried out in beds and not on ridges as at Chakan. The crop is never earthed up. This was obviously a disadvantage, and seemed to result in the prevalence of the disease termed *ubla* or *huri* (*Rhizoctonia*) which was hardly noticed at Chakan at all in the *rabi* crop. Of this, however, more later. The seed rate was similar to that at Chakan or four *pallas* (1,120 lbs.) per acre. The amount of manure was less (from ten to sixteen cartloads, or 8,000 to 13,000 pounds) though as much was put on the field as was available. The same complaint of the reducing quantities of available manure was made here as at Chakan,—but here, at any rate repeated experiments with artificial manure have been made, and made with success. They have been so successful that a market for artificial manure, when the price falls, is assured.

The average yield of potatoes at Khed is less than at Chakan as would be recognised as likely on account of the bed system of growing and the smaller quantity of manure.

The yield was in fact estimated by the people at six to eight times the amount of seed or three to four tons per acre. Ten to twelve times the amount of seed was considered very high though it was recognised that in the experiments with artificial manures even bigger yields than this (up to fifteen or sixteen times the seed) have been obtained.

The land rises to a higher plateau north of Khed, with higher but good soil, and on this plateau potato cultivation has developed extensively in a series of villages in which the cultivation is very similar. It is interesting to note that in several of these villages (including Peth) the *kharif* is proportionately a bigger crop than in the villages to the south.

In this upper plateau the soil used for potatoes is lighter than at Khed and Chakan, as has already been stated. It consists of a reddish, somewhat *murmud*-like soil, not very retentive. The best of all, as in some plots at Awasari (on lower land again to the north), is where this material has been washed down into hollows near the banks of rivers and streams. It is usually ploughed twice, then the clods are broken and pulverised, and afterwards twelve to sixteen cart-loads (10,000 to 13,000 lbs.) of farmyard manure per acre is given and mixed with the soil of the whole field by ploughing. By means of the *nangari* (working with two bullocks) furrows are made, and the cut sets planted in them nine inches apart. The sets in one furrow are covered by the operation of opening the next furrow. Then *wafas* (beds) are made, each bed being ten feet long by five feet broad, and the whole field is irrigated in the same way. The further treatment is that usual elsewhere. Earthing up is not practised.

The crop obtained from the usual sowing of 1,120 pounds per acre is on an average from six to eight times the seed used. In one very exceptional case, in beautiful soil near the banks of a stream, a cultivator claimed that he would obtain twenty times the seed or ten tons per acre. The crop

was an exceedingly good one without manure, but the yield suggested is very high for this area.

Thus taking the district as a whole, the *rabi* crop of potatoes grown by the methods described, yields about six to twelve times the amount of seed used, and in exceptional cases higher than this. From the accounts of the cultivators, it would appear that the average cannot be more than four tons per acre. Farmyard manure only is now used in growing this crop, and the amount of this available tends to decrease. The potato used was invariably the Italian white round, though a small admixture with a long red potato was almost everywhere found,—and this white round potato was stated to have the best market in Poona.

The crop grown in the *kharif* season is smaller in extent, as has already been noted, than that produced in the *rabi*. It is, of course, dependent either solely or almost solely on rainfall, irrigation being either not used or hardly used at all except in case of absolute necessity. So far as actual methods in vogue are concerned, the following differences from those already described are found.

The crop is usually grown after gram or wheat, the land being ploughed at the end of February or the beginning of March, and one or two further cross ploughings being made at intervals of fifteen days. Farmyard manure is put in heaps in the field at the end of April at the rate of twelve cartloads (10,000 lbs.) per acre. This is mixed with the soil by means of the *nangari* or small plough. After the rains commence, the soil is well saturated with water, and after the surface has become dry enough to form a friable tilth, furrows twelve inches apart are made with the small plough and the sets planted in the furrows at a distance of nine inches between them. The seed rate is about 900 pounds per acre in this season. The whole seed is then covered with a harrow and the field thus made level. The first

weeding occurs one month later and a second weeding after a further fifteen days.

Germination generally occurs at least before fifteen days and the potatoes are harvested after three months' growth. The land usually put under potatoes in the *kharif* season is not capable of being irrigated, so that failure of rain generally means failure of crop. The harvesting is done by hand digging and not by the *nangari* as with the *rabi* crop. The yield obtained is from four to six times the seed, or 4,000 to 5,000 pounds per acre, being thus less than in the *rabi* season crop. The great enemies of the crop at this season is the prevalence of rhizoctonia blight, and the attack of the *tamera* disease.

II.—THE MAHABLESHWAR AREA OF THE SATARA DISTRICT.

By S. D. NAGPURKAR, B.Ag.

While the elevation of the Khed area above the sea is from 1,800 to 2,000 feet, the Mahableshwar potatoes, grown at a much higher elevation than the greater part of the Deccan (4,000 to 5,000 feet) and near a popular hill station, have received far more attention than is justified by the extent of their cultivation or by their importance. They have been spoken of as a suitable source of potato seed, and as the home of a specially good variety. And yet the total area of potatoes in the Satara district, in which Mahableshwar lies, is only three hundred acres (297 acres in 1914-15), of which less than half lies in the area we are discussing. At the same time it is worth while to describe the conditions prevailing, the methods used, the character of the potatoes planted, and the diseases found,—the last especially, if Mahableshwar is to be considered as a source of seed.

The whole cultivation is simply a series of patches chiefly in the upper part of the Yelwa and other valleys to the east

of Mahableshwar. The cultivation is hence almost entirely by hand, but is carried on by a very industrious lot of cultivators, hard-working and intelligent. The methods used can be illustrated from those in some of the villages visited.

Two crops of potatoes are taken each year, one in the *kharif* and the other in the *rabi* season. These are never taken, however, from the same land. For the cultivation in the rainy season, sets are planted on the sides of hills one foot high. The planting takes place in June. In the *rabi* season the seed is planted in furrows, in two rows with the irrigation water flowing between the rows. In the latter case the crop is earthed up after it is one month old. Watering is given for this crop usually every fourth day, though this varies according to the soil and the special climatic conditions. Water is usually found within a very few feet of the surface and is applied by means of the well-known *pycotta*, an instrument otherwise very rarely seen in the Bombay Presidency except in Kanara.

After planting the sets are covered with farmyard manure, two handfuls per set, and then the whole is covered with soil. The sets are obtained by cutting the potato into three to four pieces according to the position and number of eyes.

After harvesting, the potatoes are sorted carefully and heaped up in a corner of the house, and covered with the leaves and branches of the fern so common in the neighbourhood. They are then separated from the rest of the house by a curtain of the same fern with a small hole for the owner to enter. No one else is usually allowed to approach the store.

Several varieties of potato are grown known by the following names:—(1) Kidney—*Khirani*—*Mumbasa*, (2) Bengal kidney, (3) *Malti*, (4) *Gulabi*, (5) *Tambada*, (6) American. The characteristics of each of these varieties will be described later. It was reported to us by old people that the original Mahableshwar potato was the *Tambada*, a red variety

which was introduced by the Chinese who were prisoners there forty years ago. It was very productive, and also kept well, but the people became careless about seed preservation, and ultimately had to buy seed from Bombay (Italian) locally called *Gulabi*. This was stated to deteriorate rapidly unless new seed was frequently obtained. The actual crop is very mixed indeed and tubers of *Gulabi*, *Tambala* and *Khirani* were picked from one heap.

The yield expected by the people, if good seed is used, is eight times the seed employed. But recently, good Bombay seed has not been obtained, and the result is that large numbers of plants die in the field before maturing and the outturn is decreasing. It is the same complaint as is found in other centres and the demand for good reliable seed is insistent.

In inspecting the crop in the field and the potato in the stores* we found that almost all the diseases which we have noticed in the Deccan were rife in this area. Among insects the potato moth was very common and did much damage, and in addition very large damage was done by the larvae of another moth (*Leucinodes orbonalis*). These cut through the stem and destroy many plants in some villages. Cutworms also do damage. The fungus and bacterial diseases were still more injurious and we found the crop in every variety riddled with (1) Ring or *bangdi* disease, (2) *Rhizoctonia*, (3) a disease termed *k̄huzali* by the people, shown to be powdery potato scab (*spongospora*) and (4) a disease in which the top of the plant looks as if burnt up, and now found to be caused by a mite (*Tambora*). We will deal with each of these diseases in a later chapter. We may emphasise, however, that the crop near Mahabaleshwar is now as much riddled with disease as anywhere else in the Deccan. The idea which has been put forward that we may look to Mahabaleshwar for fairly disease-free seed is quite wrong. If used, as many precautions will have to be taken here as elsewhere.

* We had the invaluable help of Professors Ajrekar and Kasargode of the Poona Agricultural College in examining these crops.

The potato crop is also grown in other parts of the Satara district to a small extent. These areas lie at about the general level of the Bombay Deccan (2,000 feet) and the methods do not differ widely from those used in the Poona district. The principal areas are round Koregaon and Wathar, whence the produce can be easily booked to Poona or Bombay. The *kharif* crop is by far the most important and the dominant variety is the same as that found in the Khed tract.

The potatoes of the district are riddled with the diseases found elsewhere. In addition a scale insect on the underground stems, roots, and young tubers was noticed in the village of Pimpli near Wathar. This has apparently not spread at all, and is at present very rare.

III.—POTATO-CULTIVATION NEAR BELGAUM AND DHARWAR.

By S. D. NAGPURKAR, B.Ag.

In the south of the Bombay Presidency, in Belgaum and Dharwar there lie other islands of potato cultivation, and the methods adopted command some interest.

In Belgaum the area has been very concentrated in the neighbourhood of the town, and has been of a very intensive character, yielding very high returns. The area has never been more than a few hundred acres, and the potatoes have been almost exclusively grown in the *rabi* season. The land, having borne a crop of rice or grass in the previous rains, is ploughed up in September or as soon after as the previous cropping allows. Four times the plough is run over the land, the clods being broken up by hand and stubbles collected after each ploughing. After harrowing, ridges are made, at a distance of one foot, with the country plough and beds, eight feet by six feet, are prepared for irrigation, three rows being in each bed.

Potatoes are planted first in the furrows in the first week of October or as soon after as possible, and harvested in the following January or February. The sets are planted very close together in the row, the distance being often not much more than four inches. As the plants begin to grow they are earthed up. The seed rate required is, hence, very high, usually about 1,800 pounds per acre. Watering is given every eighth day in the first month, every fourth day in the second month and again every eighth day in the third month. The land is weeded twice during the growth.

If potatoes are taken after rice, no manure is given; if after grass twenty-five cartloads (20,000 lbs.) of farmyard manure per acre. The average yield is from 10,000 to 13,000 pounds per acre or six to eight times the seed used. As has already been stated, the cultivation in this area is very intensive, and the edges of the water channels in these potato fields are usually planted with cabbage and knol-kohl, which add to the return given by the potatoes. The cultivation altogether is exceedingly good and the potato fields near Belgaum show one of the most attractive forms of agriculture in the Bombay Presidency.

In Dharwar, sixty miles to the south of Belgaum, a very different type of potato cultivation is in vogue. Here the crop is taken exclusively in the *kharif* season, as there are few wells and hence little irrigation in the tract where potatoes are grown. The Dharwar cultivators usually get their seed from Belgaum, this being reaped in January or February and planted in the following June.

The fields in which it is intended to plant potatoes are first ploughed two or three times at the beginning of June after the first rains have been received. The land mostly used is a reddish, fairly porous but deep soil, though some potatoes are also planted on black soil. After harrowing furrows are opened by means of the plough, five to six

inches deep, and three feet apart. Thus the planting is far wider than anywhere else in Western India, and in recent years an intercrop of cotton or chillies is often taken between the rows. A man follows the plough with a basket of farmyard manure, and two handfuls are given for each potato set planted. The sets are put down at twelve to fifteen inches apart in the rows, and each set is placed on the small heap of manure, and partially covered by the hands, with earth and manure. Then a small harrow is passed over the field and the ridges levelled.

When the sets have germinated,—the shoots usually showing above ground after fifteen days,—the land is hoed, further hoeings following at intervals of a month. The hoe used is so arranged as gradually to earth up the rows of potatoes. The plants grow vigorously, the larger space leading to larger and more vigorous plants than are found elsewhere in the Bombay Presidency. This does not mean a very high yield per acre as the amount of seed used is small. From 300 pounds of seed per acre, a yield of 1,500 to 2,000 pounds of crop is expected with the quantity of manure used.

The diseases found are similar to those noted in the *kharij* crop elsewhere. Ring disease is common, and the potato moth is stated to have almost ruined the cultivation as the produce cannot be stored. Rhizoctonia wilt is most common, and the *tambora* disease is rampant and annually reduces the yield to an enormous extent. Among minor pests, the stem borer (*Leucinodes orbonalis*) is very common.

The area here has been very largely reduced on account of shortness of seed, due to the famine of 1918, and the impossibility of importing Italian seed. The potatoes grown at Dharwar are largely bought by Bangalore merchants for seed and it is stated that they prefer for this purpose the tubers grown in black soil.

IV.—CAUSES OF THE LOW YIELD OF POTATOES GENERALLY.

By H. H. MANN, D.Sc., AND S. D. NAGPURKAR, B.AG.

The chief causes of the low yield which prevails over most of the potato areas described seem to be three. The first is that usually a large proportion of the seed potatoes do not germinate. The second lies in the fact that the seed is generally so infested with disease, chiefly potato moth and the bacterial 'ring' disease that either the vitality of the plants is damaged, or they almost inevitably die before the crop is ripe. And, thirdly, there are several diseases of the crop in the field, most of them different from the great potato scourges of temperate climates but nevertheless equally important here, which either kill the plants or reduce their yield, particularly in the *Kharif* season, to very small dimensions. Beyond these causes, the manuring given is by no means sufficient to secure a full crop, and as we shall show, this can be very largely increased by more adequate fertiliser dressings than the people are at present ready to use.

With regard to the losses of plants commonly found due to lack of germination or to disease attacking the potato plants in the field, the effect can perhaps best be seen by actual counts of the number of missing plants in fair average fields of growing potatoes. We have actually counted the blanks in growing fields on several occasions in the Khed area, and the following figures give the results of some of these :—

- (1) At Khed an average field was taken and forty-five per cent. of the plants which should have been there were found to be missing.
- (2) At Peth a similar test made in a particularly good field gave twenty per cent. of blanks, and an average field showed forty-one per cent.

How far this excessive loss is due to faulty germination and how far to each of the prevalent diseases is not yet quite clear, though certain indications have been obtained. But it would appear that, from one cause or another, there are, on the average between thirty and forty per cent., less plants in the fields of ripening crops than there ought to be.

As to the failure of germination, the people use the term '*rutu*' to express the condition of the seed tubers when they are ripe for germination. So far as the *rabi* crop is concerned, the people in the Khed taluka said to us that they prefer Italian seed because it arrives in a condition in which it is ready to germinate (*rutu*), whereas, owing to difficulties of storage (on account of high temperature, etc.), the local seed is not usually ready to sprout when planted. This is, in popular opinion, one of the chief reasons for the superior yield given by Italian seed.

Potatoes intended for seed are usually reaped slightly before the rest of the crop, when the leaves over most of the plants are yellow but when those at the top remain green. This is, of course, not an infallible guide but gives an idea of the condition which it is generally considered should be reached. When so reaped they may be considered as slightly immature, but their utilisation as seed is in accordance with the latest opinion in Europe, where the use of such slightly immature seed potatoes is considered to promote earliness, vigour, and resistance to the effect of bad seasons.* When reaped, however, they will only germinate to a very small extent, and they have to be stored for several months to become *rutu*. We attempted to germinate sets, very carefully selected from plants in the best condition, immediately after digging up in October. Only about ten per cent. in thirty-three days, and forty-five per cent. more in sixty-three days, germinated. Only when the dug potatoes are green from having been exposed to the air during growth is a higher percentage

* See Hutchinson—Journal of the Board of Agriculture, Vol. 23, page 529 (1916).

of germination obtained. In ordinary cultivation more than twenty-one days to germinate is considered as unlikely to give a decent plant, so that fresh seed, however carefully selected, is quite unsuitable for growing a crop.

But while some eyes do sprout immediately after digging, if the potatoes are kept for a week or more no germination whatever is obtained unless they have been stored for two months at least. This loss of germinating power, after keeping for a few days has been noticed several times, and so storage of seed for a *considerable* time is needed. How long this should be, under Deccan conditions to get the best results has been carefully tested with potatoes reaped in October, and planted from December onward. The following table shows the percentage of germination in two weeks and three weeks respectively with potatoes stored for varying lengths of time :—

Length of storage.		Percentage of germination in 14 days.	Percentage of germination in 21 days.
2 months	..	<i>Nil.</i>	<i>Nil.</i>
2½	..	<i>Nil.</i>	25
3	..	15	40
3½	..	40	70
4	..	50	80
4½	..	60	85
5	..	70	92
6	..	80	95
7	..	100	100
8	..	80	85
9	..	60	70
13	..	40	60

These figures show that in the months from October onward in the Deccan storage for two months is not enough, and that the germinating power gradually increases until the potatoes have been kept for seven months. After the hot weather starts the temperature has to be kept down below

90°F. or rotting will commence (see Chapter IX). If this is secured the potatoes keep well, but ultimately shrivel and dry up. This is apparently the cause of the progressive loss of germinating power after seven months.

If the *rutu* condition is to be obtained, as a rule, therefore, in places where both *kharif* and *rabi* potatoes are sown, it will be necessary either (1) to hasten the changes taking place in the stored potatoes so that they may become ready within two months or (2) to store potatoes from the *rabi* crop for the following *rabi* season, and similarly from the *kharif* crop for the following *kharif* season. This alternative means keeping the potatoes for six months.

If the hastening of the *rutu* condition (No. 1) could be produced it would be a great boon in the matter of getting good germination. This can, in our experience, be secured to a small extent by fumigation (as described in the next chapter in connection with the potato moth) followed by storing in bags, as against storing in single layers under sand. This increase in the rapidity of becoming ready for germination, may in the case of storage in bags be due to the somewhat higher condition of temperature which there prevail coupled with a moist atmosphere among the stored potatoes. But the matter is one for which the reason cannot be definitely given.

As regards the other alternative mentioned above (No. 2) it is avoided by the people owing to the difficulty of storage as a result of attack by the potato moth, of the prevalence of dry rot (*fusarium*) and other rots in almost all Indian seed, and (in the hot weather) of the very large loss caused by the heat-rot to be described in a later chapter. To avoid these difficulties means rigid selection and careful fumigation of the potatoes selected for seed, coupled with special storage arrangements whereby the temperature can always be kept below 90°F. at least. We have carried out these methods and have succeeded in obtaining after six months storage

excellent seed potatoes in precisely the same condition as the potatoes imported from Italy at the time they arrive. There now seems no doubt of the feasibility, with due care, of keeping seed potatoes for six months on the Deccan, though it is now never done. We will deal with this matter in the chapter on potato storage (Chapter IX).

The actual amount of failure of plant in average fields has been indicated at the beginning of this chapter, but the figures there quoted were taken when the crop was nearly ripe, and so included all the later losses due to disease attack in the field. A better idea of the amount of failure of plant due to deficiencies of the seed was estimated in the fields not more than two months after the planting of the sets. Good fields only were chosen as it was wished to ascertain the losses in the best practice, and those sets, which had germinated so late that they would never produce good plants, were counted as failures. The estimation was made in the *kharif* season. Thirty such fields were taken, and a row or bed selected at random which should have contained one hundred plants was counted. The actual number of plants, on the average, was twelve per cent. below what it ought to be, but the variation was very large even among good fields. The following statement shows the condition in more detail :—

	Per cent.
Fields with 95 per cent. of the proper number of plants or over	26
Fields with 85 to 95 per cent. of plants ..	40
Fields with 75 to 85 per cent. of plants ..	17
Fields with less than 75 per cent. of plants	17

These figures it must be remembered indicate the state of affairs in fields only which are recognised as good and probably above the average. They also indicate the condition during the early part of growth and before the greater part of the considerable mortality from ring disease and

rhizoctonia occurs. They show that it is possible, with the knowledge possessed by the cultivators, to get good germination with much shorter storage than is indicated in the table given above.

Failure of germination may be due not only to the potatoes not being *rutu* but also to moth attack of the seed during storage, and to the prevalence of the *bangdi* or ring disease, as well as other diseases of the potato tuber. The moth attack and the *bangdi* disease are the most important, by far, however, in the Khed area and they are throughout the district the most dreaded enemies of the potato cultivators.

Careful cultivators in fact take considerable pains to eliminate potatoes seriously affected by moth as well as those attacked by ring disease from the potatoes actually sown. This is done because any eyebud attacked by moth will not germinate,—and a seed potato affected by ring disease will produce a plant which will inevitably die and may infect others. In spite of this a good deal of both useless and diseased seed is sown. We made, in fact, an examination in a large number of cases of the seed ready cut and actually being sown to determine how far the loss of plants was due to seed, with the following results.

We examined the seed being used in thirty-nine fields in the Khed area. Taken altogether, out of 3,856 sets examined :—

- (1) 2,669 or 69·2 per cent. was sound and good seed.
- (2) 253 or 6·6 per cent. was affected with *bangdi* or ring disease.
- (3) 296 or 7·7 per cent. was injured by moth so that some of the eyes would not germinate.
- (4) 135 or 3·5 per cent. were so injured by moth that none of the eyes would germinate.

(5) 367 or 9·5 per cent. were attacked with dry rot (*fusarium*).

(6) 136 or 3·5 per cent. of the sets had no eye-buds and so *could* not germinate.

Thus we have seven per cent. of the sets which could not possibly germinate at all (Nos. 4 and 6). We have 6·6 per cent. remaining after all elimination has been done, attacked by ring disease (No. 2). These were cut (as they always are) with the same knife (see page 47) as the other sets. The sets partially attacked by the moth would be of variable value, but at least half would produce no plants or at most very feeble ones. The effect of the *fusarium* (dry rot) on the potatoes for seed will be discussed later (Chapter VII). But the fact remains that on the average of thirty-nine separate fields, little more than two-thirds of the seed used was entirely sound in 1917.

Of course the average just given is not quite a fair figure to take. The best cultivators used seed absolutely sound and capable of germination, and the actual character of the seed sown in the different cases is summarised below :—

Proportion of seed sound and capable of germination. Per cent.	Proportion of cultivators using each quality of seed. Per cent.
100	10·3
90-100	7·7
80-90	20·5
70-80	30·8
60-70	5·1
50-60	5·1
40-50	5·1
30-40	5·1
20-30	2·6
10-20	5·1
Under 10	2·6

In many of the worst cases the chief disease was *fusarium* (dry rot) which at any rate does not prevent germination.

But, on the whole, these figures show in what a bad condition is the seed planted in a large proportion of cases. 61·5 per cent. of the cultivators were using seed of which less than 80 per cent. was sound, healthy and capable of germination.

Leaving on one side at present the question of dry rot (*fusarium*) it will be seen that the principal diseases which spoil the seed are, as has already been stated, the potato moth (*Phthorimea operculella*) and the *bangdi* or ring disease.

The potato moth attacks the potatoes when in the field they are exposed owing to inadequate earthing up, and after digging, whether they are in the field or in the store. We will describe the work and its effect, both elsewhere and as it affects our areas, in the next section, but it may be said that when it occurs and the caterpillar has been working in the tuber, the germinating power is lost. The eggs, in fact, are laid in the eyes, and the young caterpillars destroy the germinating power even before they have seriously harmed the potato from an edible point of view. If no special precautions are taken the extent of attack in the storage of seed potatoes may be very large indeed. An attack of 75 to 80 per cent. of the tubers is not unknown, and the people in the Khed area estimate the average damage at ten to fifteen per cent.

The *bangdi* or ring disease, though not so important as the moth attack when the latter was unchecked, is much more difficult to deal with and is, on the average, perhaps the greatest source of loss so far as germination is concerned and during the growth. We will deal with the subject separately, but the cultivators were unanimously of opinion that the principal source of loss by ring disease is by using diseased seed. If the seed is far advanced in the disease, germination does not occur,—if it is only just begun, then the plant will die in the field after a month or two. It can, from the experience of the people, only be checked by the use of Italian seed, or seed carefully bred so as to be free from the disease.

Another possible source of loss of plants in the field, is the planting of potatoes at an unsuitable time of the year. There are two main crops in the Poona district, as has already been described, but the times during which these can be planted has not hitherto been very exactly defined. Generally it may be said that the *rabi* crop may be planted if *rutu* seed is available (which is not usually the case) from October in the Khed taluka, but that the latter half of November is considered to be the best time. Planting may go on up to the latter half of January, but after this date it is too late. Experiments as to the latest date were made at Chakan in 1920 with excellent seed imported from Italy. The seed planted on January 19th gave a yield of eleven times the seed used. From this date the yield with the later planted seed went steadily down, and that planted on February 10th only gave a yield of twice the seed used. In seed planted on the Deccan on March 1st, no crop was obtained. This is caused, as will be seen, by the rotting of the sets used in the hot soil, and by the very intense attack of the *tambora* disease if the potato crop is in the land in April and May. These dates apply to the Italian potatoes usually grown. All other English and exotic types were far more sensitive and failed when planted earlier.

The *kharif* crop is usually planted in June, but may be and is planted earlier (in May) in certain villages, notably in Pabal (Sirur taluka, Poona district). But to do this very special precautions have to be taken. The land must first be flooded with water, then allowed to dry until it can be worked and brought up to a good tilth. This watering is, we believe, largely given for the purpose of reducing the temperature of the land so as to render it fit for potato planting as the maximum shade temperature in May is often nearly 100° F. Then the sets are planted and watering follows immediately.

The other causes of low yield, namely, the very prevalent field diseases like *tambora* and rhizoctonia blight, which

affect the *kharif* crop in particular, will be dealt with in their place.

V.—THE POTATO MOTH.

BY R. S. KASARGODE, L.AG., AND S. D. NAGPURKAR, B.AG.

Inasmuch as the potato moth is considered by the people to be perhaps their worst enemy and as it is a very generally widespread pest over many of the potato growing regions of the world, a special account of the insect drawn from all these sources, and of the work done against it elsewhere and its application to our areas, may be of some advantage.

The potato tuber moth (*Phthorimea operculella*) is very widespread in the potato growing regions of the world.* It is a destructive pest of potatoes in the Mediterranean, in the United States and in India.† In America it is considered the worst potato pest in California, and from there it has spread into surrounding states, including Texas.‡ In Australia it is considered the most troublesome pest all over the country,§ and it was in Tasmania that it was first noticed. In India it "has spread over Bombay, the Nilgiris, the Central Provinces and as far east as Patna".¶ In the south of India it occurs in all potato growing districts up to an elevation of 6,000 feet.¶ There is a suspicion among the people in Khed that it was introduced here in Italian seed, but whether or not, it is generally established here now.

In connection with its introduction into our areas, it is important to note that the people themselves in the Khed area here never had any doubt that it came as the result of using

* The most recent and complete account is by Graf in U. S. Department of Agriculture, Bulletin No. 427 (1917).

† Lefroy—Indian Insect Life.

‡ U. S. Farmers' Bulletin 557 (1913).

§ Steward—Rept. Aust. Ass. Adv. Sci. 1913.

¶ Fletcher—Some South Indian Insects, Madras, 1914.

Italian seed. In the early part of 1907 the late Mr. Dixon* after a visit to the Khed villages reported as follows :—“ The story of the Khed cultivators was that the potato worm came to their notice for the first time about ten years ago after they had received, from the Department of Agriculture, European potatoes for sowing in the taluka. The Junnar cultivators stated that they also had received for sowing purposes European potatoes from the Department of Agriculture fully ten years ago, but added that the potato worm only attracted their attention six or seven years ago.” In 1907 the pest, according to Mr. Dixon, occurred in every potato growing village of this area.

Mr. Dixon made inquiries also, in the same year, about the matter in Northern Gujarat and reported as follows† :—“ The Deesa cultivators stated that the potato worm attracted their attention for the first time about six years ago. From that time they gave up the Poona potatoes and began to import Italian potatoes direct from Bombay regularly every year. The men added that over three years ago the worm appeared again and the pest was so bad that the damage done to the potatoes varied between fifty and seventy-five per cent. . . . The statement of Ahmedabad cultivators was that they saw the potato worm for the first time about seven years ago and added that about four years ago the pest was so destructive that their losses amounted to fully fifty per cent. . . . The potato worm has been known to the Bombay merchants for the last eight years.”

There is thus very strong evidence to show that the pest is a recent one and that it was introduced with Mediterranean seed, obtained to counteract the effect of the *bangdi* or ring disease.

The caterpillar attacks growing potato plants, feeding on the leaves by mining into them, and similarly affects

* Report, dated April 2nd, 1907.

† Report, dated May 28th, 1907.

tomato, brinjal and tobacco* in America, though not in India,—but on none of these is the injury serious at this time. The serious character of the pest is determined by the fact that the moth lays its eggs on the potato tuber, in the cavities containing the eye buds, either while the tubers are still in the ground but exposed, or after they are dug up and exposed either in the heaps in the field or in the store. When eggs are laid in the eyes of the potato, on hatching, after a very few days, the caterpillars penetrate the potato (incidentally destroying the germinating capacity of the eye bud) and feed inside the potato, forming regular burrows which are filled with refuse, while the potato becomes uneatable. The presence of the caterpillar in the potato can be seen by the presence of excrement on the outside. It forms its pupa inside the potato or on the outside, and the moth comes out about a month after the eggs were originally laid, at any rate in the hot weather of the Deccan.

The actual length of time in the hot weather at Belgaum required for each stage of the life history of the insect was determined by us in 1910-11 as follows:—

Egg stage (on the potato tuber) ..	6 days.
Larval (caterpillar) stage (inside the potato tuber) ..	28 days.
Pupal stage (inside or on the potato tuber) ..	12 days.

Each female moth lays from twenty-five to twenty-nine eggs.

The insect is, therefore, obviously a pest of stored potatoes. If good seed is used, and the potatoes during growth are well covered up, it affects the growing crop practically not at all. But when the potatoes are stored, enormous damage may be done. In Khed and elsewhere in Western India the chief trouble has been to preserve the seed potatoes, for

* In America it has also been found on *Solanum torvum*, *Solanum verbascifolium*, *Solanum canadense*, *Solanum nigrum*, *Physalis peruviana*, *Physalodes*, *Datura stramonium*.

the crop is sold off as soon as possible after reaping, and the preservation of it afterwards is a matter, the people think, rather for the merchant than for them. The difficulty of storing for seed, however, touches them closely, especially as cases have been known where as much as 75 to 80 per cent. of the stored potatoes have been spoilt. Of course it is obvious that the price of the whole crop must be lowered by the loss which the moth is liable to cause, and hence, though a method of storage free from moth for the whole crop is required,—the most urgent need is for a method of keeping the potatoes stored for seed free from moth.

This has been felt elsewhere in India, and experiments have been made and recorded in Pusa, the Central Provinces, and particularly in and near Patna as to the best method to adopt to secure this.

A. In Pusa* the attempt was to ascertain the best material to use to cover the stored potatoes so as absolutely to prevent the pest laying its eggs on them. The conclusions were that the best way of storing potatoes so as to save them from moth was to keep them spread out in thin layers in sand, or in sand mixed with naphthalene, or in charcoal. To store in ashes was fatal: all the tubers quickly dried up and perished. In any case from the point of view of keeping the potatoes from rot, it was better to spread them out in thin layers than to heap them in bags or baskets. Again, dipping the potatoes in lead arsenate, in crude oil emulsion, and in copper sulphate all prevented moth attack almost completely. Some of these methods could not obviously be used on a large scale, but others seem decidedly applicable.

B. In the Central Provinces the method recommended and adopted for storing *seed* potatoes, is to dip them in crude oil emulsion solution, and then store in baskets under sand. The actual process was to mix $1\frac{1}{4}$ lbs. of crude oil emulsion as bought in Bombay with four gallons of water and

* Agricultural Journal of India, Vol. V, page 20 (1910).

stir. The selected seed potatoes were then dipped for five minutes and then stored in baskets under sand. The potatoes were stored for periods up to 4½ months, and were then found quite free from moth. The amount of rotting from other sources was considerable, but the method seemed quite satisfactory as a preventive of moth.

C. An extensive and long continued series of experiments have been made by Woodhouse and Dutt at Patna, on storage in sand.

The period for which potatoes are stored in Patna is obviously much longer than with us, where seed is practically never kept more than two or three months at the longest, and where potatoes grown in the *kharif* season are used for the *rabi* crop and those grown in the *rabi* season for the *kharif* crop. In Patna, however, the method of dipping in crude oil emulsion as a protection against moth was a failure and led to more rotting of the tubers than was the case without it. The system of storing under sand has, however, been a great success, and extended so far that five years after the introduction of the method no less than 186,000 maunds (6,500 tons) were stored by this method in 1914. The actual instructions issued to the people in the province were as follows :—

(1) As a preventive measure the ridges in the potato field should be made fairly wide, not less than a foot, so that the chances of tubers being exposed.....may be minimised.

(2) As soon as the harvested potatoes are fairly air dried, the affected tubers and the bruised and cut tubers should be removed.

(3) The healthy tubers should then be stored in a godown preferably on a high *machan* (platform). Cloths should be spread over the platform with one inch of dry river sand, and then the potatoes to a depth not more than a foot. All should then be covered with dry sand so that no

tubers can be seen through the sand. After a month they should be taken out of the sand and the damaged tubers removed. As soon as moths disappear from the godown the heap should be left exposed but a watch should be kept for the moth, and if it appears the potatoes should be at once covered.

(4) Storing should not be done in a hot dry godown, owing to loss by diage.

(5) Insect-affected or rotten tubers should be burnt or buried underground.

If these instructions are carried out it is stated that 60 per cent. of the weight of the stored potatoes will be found good at the end of the season.*

Such is an account of what has been done to prevent damage to potatoes, and to seed potatoes in particular in other parts of India. Outside this country reliance has been placed chiefly not on dipping of the potatoes or simply on storing them so that the moth cannot get at them, but on fumigating the potatoes coupled with clean cultivation so that the weeds on which the insect lives may not be present. In America† the recommendations which seem to have been effective are as follows :—

(1) “The first measure consists in the use of clean methods of cultivation. This implies that all infested potato plants and solanaceous weeds such as ground cherry, bull nettle, horse nettle, and volunteer potato plants growing in the same vicinity as the potatoes, must be destroyed. This can be done by prompt burning as soon as insect infection is manifest. The burning of these weeds will eliminate places for the breeding of the insect or for its successful hibernation. Domestic animals, such as sheep and hogs, are valuable for the destruction of remnants and may be utilised by merely turning them into the field.”

* Woodhouse and Dutt—Bengal Agricultural Journal, April 1911 (page 188); January 1912 (page 146).

Bihar Agricultural Journal, Vol. I (1913), page 115; Vol. II (1914), page 48; Vol. III (1915), page 69.

† See Farmers' Bulletins Nos. 557 (1913); U. S. Bureau of Entomology, Circular No. 162 (1912).

(2) The potato crop should be alternated with other crops not attacked by these insects.

(3) Dug potatoes either whole or cut should on no account be left in the field.

(4) The tubers should be fumigated with bisulphide of carbon or hydrocyanic acid gas. With bisulphide of carbon, three pounds for 1,000 cubic feet of space should be used, and the potatoes left exposed to it for 24 hours in a closed vessel, barrel or box. By this means all the moths, in every stage, are considered to be killed.

With hydrocyanic acid gas a special chamber is needed, as the gas is very poisonous, but the fumigation is more effective than with other materials and the potatoes are not damaged.

In Australia, the pest has been dealt with by fumigation and carbon bisulphide is preferred to all other materials, for the purpose. The strength required is stated to be as follows :—

(1) For the caterpillars—15 to 16 hours with 1 to 2 pounds of carbon bisulphide per 1,000 cubic feet.

(2) For the pupa—48 hours at the above strength, and it is then not always successful.

(3) For the eggs—48 hours at the above strength, and a second treatment may be needed after six days.*

So much for methods used elsewhere. In the Khed taluka the difficulty has been felt exceedingly. For fear of the moth (and of rotting, of which more later) the main crop of potatoes is sold as soon after harvesting as possible, and only enough is retained as is required either for seed or for exchanging with another cultivator for seed. The importance of earthing up the potatoes in the field is recognized by the better cultivators,—but the question of storage against the moth has hitherto been an unsolved problem so far as the people are concerned.

* Steward—Report Austral. Ass. Adv. Sci., Vol. 14 (1913).

To show clearly and emphasise the importance of the fact in this area, we may quote an unpublished note by Mr. Keatinge written in 1909 since which time the pest has certainly not been getting less serious. Mr. Keatinge then wrote "All over the Khed taluka the potato growers complain greatly of the borer and say that it does greater damage every year. Almost every *bagayat* village complains of the thousands of rupees worth of damage since the rains,* and many individuals complain of hundreds and even thousands of rupees lost. From what I have seen I do not think that they exaggerate. I have seen many potato stores. Most of them are half ruined and some are absolutely ruined, the potatoes being reduced to a rotten mass swarming with worms. On all sides it is said that it hardly pays to grow potatoes now owing to this pest, and many are talking of giving it up. I find that many persons know that the worms come from the eggs that the moth lays, and they have tried to prevent the moth from getting at the potatoes by putting them in pits covered with earth, and by covering up the heaps with teak leaves, and throwing water over them every day. The first plan is very unsuccessful, and I have seen such pits of rotten potatoes,—but the second plan seems to afford some small relief."

The actual method of storage in vogue at Khed is as follows :—The potatoes are harvested before the plants turn yellow and the potatoes turned up by the first ploughing are alone taken for storage. The remainder, the green coloured potatoes, and those spoilt in any way are put together and sold at once. Then the potatoes to be stored are heaped in a flat dug out area which is specially prepared for the purpose. This is usually ten feet long, five feet wide and eighteen inches deep, and it is dug either under a roof or under the shade of a tree. It is first filled with water, the water

* This note was written in December.

allowed to soak away, and then the space allowed to dry for five days. Then the sorted potatoes are heaped upon it generally to a depth of three to three and a half feet, but sometimes as deep as four to five feet, and covered with a thick layer of grass or broad leaves. Then a ditch is dug round the heap at one or two feet distance, and this is occasionally filled with water. Sometimes, though not usually, the heap is splashed with water. Such a heap, which may remain up to three months, is very carefully tended. No one is allowed to open it on any pretext, as this is considered to be very injurious.

When moth gets into such a heap it does enormous damage, and the people are helpless. The only things they have tried have been to put *neem* (*Melia indica*) leaves into the heap,— and to put sugar on the heap to attract ants which were supposed to attack and eat the caterpillars.

A considerable number of experiments on the potato moth, and particularly on the storage of potatoes so as to avoid the moth have been carried out in Western India at Belgaum, at Dharwar, in the Khed taluka, from 1906 onward, the result of which we may shortly summarise.

(1) In 1906 at Belgaum* it was shown that the potatoes as harvested were free from moth, that steeping in 1 per cent. copper sulphate solution reduced attack by more than half, but if the copper solution was washed off after treatment the tubers were attacked more than ever.

(2) In 1907-1908 at Belgaum† it was definitely proved that the use of seed attacked with moth, provided it will germinate, does not in any way lead to moth attack in the crop, and that grubs once buried in the ground along with the potatoes die in them and never from moths. The importance of earthing

* Dharwar Experimental Farm Report, 1906-07.

† Dharwar Experimental Farm Report, 1907-08, 1908-09, 1909-10,

up in the field to prevent attack there was also clearly demonstrated.

(3) In 1913-16 in the Khed taluka careful experiments were made by Kogekar on the storage of potatoes, the results of which we are allowed to quote, though they have not been yet published. Fumigation with petrol vapour was found to be a complete preventive of moth provided the potatoes were afterwards stored either on racks in airy rooms where moths could not get at them or under sand, or even in bags.

It will be seen from these accounts that the actual prevention of moth attack seems to present no difficulty in theory. If the potatoes are earthed up in the field, are rapidly taken away after lifting, and are stored where the moth cannot get at them, whether on racks in a moth proof room, or under sand, or in bags, the moth danger ceases. If the potatoes are attacked, careful fumigation with petrol vapour, while not completely eradicating the moth, almost does this and on storage afterwards there is no appreciable attack.

But a practical difficulty at once comes in. If the potatoes are stored under conditions protected from moth, whether under sand, or on racks in a moth proof room, or in bags, the percentage of potatoes rotting from other causes is so great that the method fails on this account. As a practical method the only alternative in the Khed area to the field method of storage described above is to keep the potatoes in bags, and this led to very large losses (even up to 58·8 per cent. in one case) from various rots, even after the moth had been got rid of by fumigation.

The method of fumigation had therefore not become used at all until 1917 when we undertook further inquiry with the storage of potatoes on behalf of the cultivators. Our experiments against potato moth were carried out with the full co-operation of the cultivators and a large group of men from each of four or five of the important potato growing villages gave every assistance. They were, however, quite

unwilling to consider any experiment which involved dipping the seed potatoes before storage, or which involved storing in buildings on shelves in sand. In the last case they said that the method would involve more space and more cost than they would be able to afford. The method of fumigation seemed much more likely to succeed, and potatoes were placed at our disposal for the purpose.

Previous experiments which we had conducted had shown (as already noted) that fumigation of potatoes by petrol vapour while not effective in killing quite all the eggs and pupae of the moths, yet, when selected potatoes were used, was quite sufficient to reduce the amount of moth in the potatoes to very small dimensions. In India any method depending on carbon bisulphide is almost inadmissible; the material is very dear, its use is difficult and dangerous, its carriage is only made under considerable restriction. Petrol is, on the other hand, comparatively cheap, and though not quite completely effective, its vapour is very valuable with the larva at any rate, and to a certain extent with the pupa but not with the eggs.

It was essential too that the fumigated potatoes should be stored in bags. This seems to be fatal in Bihar, and has given rise to difficulties in Belgaum and Dharwar as well as in Khed, through rotting. But unless it can be done, the fumigation, under the conditions of the Khed taluka did not appear likely to succeed. The basis of the method adopted was, therefore, the fumigation of carefully selected potatoes coupled with after storage in bags. The success of the method has been considerable, in spite of the rotting difficulty, which we have been able to deal with to a large extent. The plans employed in dealing with the rotting will be described in the chapter on potato storage.

The fumigation itself of potatoes intended for seed has now become an established practice in a number of leading villages in the Khed potato tract, and per-

manent fumigation chambers have been established in the charge of a village committee in these centres. The fumigation chambers are built of brick, cemented inside to make them gas tight, and are seven feet in internal diameter and six feet deep. The bottom is paved with Shahabad stone. Each will contain about two and a half tons of potatoes in bags. The top of the wall, all round, has a depression in which water can be placed, so as to form a water seal, which is gas tight, when the cover is put on. The cover is either made of iron, or of wood with an iron ring to fit into the depression on the top of the wall. If this arrangement is used a very simple method of securing the gas-tightness of the fumigation chamber is obtained. The appearance of the chamber is shown in Plate I.

The bags of potatoes are put into this chamber, having been as little as possible exposed to the possibility of moth attack after digging. The potatoes are not fumigated until a fortnight after being harvested. Several tin trays containing cotton wool are placed on the bags in different parts of the chamber, and two and a half pints (50 ounces) of petrol poured over the cotton wool. The cover is then immediately put on, and the whole left for twenty-four hours. This is found sufficient to kill the moths and caterpillars, to damage the pupae if any are present so that they will either not emerge or come out only in a weak form, but it does not really affect the eggs. Hence it is important that no chance should be given for eggs to be laid on the tubers immediately before the fumigation takes place. In any case a second fumigation, ten days later, is necessary to get rid completely of the insect, but it rarely pays to give this second treatment.

After twenty-four hours the chamber is opened and the bags removed, and stored in as cool a place as possible. The question of the best conditions for this storage will be dealt with later.

VI.—THE RING DISEASE OF POTATO.

BY H. H. MANN, D.Sc., AND S. D. NAGPURKAR, B.AG.

If the potato moth is the enemy of the crop which gives the greatest concern to the cultivators it is very closely followed by the trouble given by the so-called *bangdi* (or ring) disease or 'bangle blight', which has been in the district for very many years, and whose prevalence was the cause of the first investigations and inquiries into the crop made in the early nineties by Cappel and Mollison. The results of that inquiry are contained in the bulletins issued by the Bombay Agricultural Department in 1892 and 1893.* These were summarised by Butler in 1903,† and we shall quote parts of the description which he gives—

"A disease known to the native cultivators by the name of *bangdi* disease, from the appearance of a dark ring visible on sections of the substance of the potato, was brought to the notice of the Department of Land Records and Agriculture, Bombay in 1893. It affected the crop of the Khed and Junnar talukas whence the greater part for the supply for the Poona and Bombay markets is drawn. Shortly afterwards it was reported to occur elsewhere in the Poona district and in Gujarat and Mahableshwar. It was stated to have first appeared some three or four years earlier.‡ By 1893 it had been found widely distributed in India: at Bangalore, in the Nilgiris, in Bengal and all through the Bombay Presidency."

Since that time it has become well known almost everywhere in India. "In Mysore", says Coleman, "it is to be

* Cappel—Note on the Potato disease prevalent in the Poona District and elsewhere, Poona 1893.

Cappel and Mollison—Second Note on Potato disease prevalent in Poona, 1893.

† Agricultural Ledger No. 4 (1905).

‡ This is undoubtedly incorrect. The disease was of old standing by all local informants.

found in practically every locality where potatoes are grown. The extent of its ravages is certainly very much greater than is generally supposed."

"Not only in India," continues Butler, "but in almost every country it appears to be now well recognised if we can as seems probable, identify the disease with the 'potato rot' of America. Of this, it may be said that it attacks not only potatoes, but also many other solanaceous plants such as tomato, tobacco, brinjals (egg plants), datura and others."

It is known, as already stated, in nearly all parts of the United States except the north, in the West Indies, in Java and Sumatra, in Australia, in Rhodesia, and probably in Russia, Great Britain, France and Italy. We have recently found it, in small amount only, in seed potatoes imported direct from Italy.

The disease, as it occurs among the plants, is very striking. "The first symptoms, externally, of the disease is a 'wilting' of the green top, which occurs suddenly. A plant may look quite well one day, show signs of fading the next day and droop on the third day. This does not occur generally throughout a field, but scattered plants every where are seen withering in the midst of green ones. The tuber is arrested in growth so that the crop where disease is severe is generally poor and composed of small tubers. Many are rotten when dug and others rot in quantity in storage. The disease appears only as the crop approaches maturity, and at first even when the discoloration of the stalk just under the surface of the soil is apparent, the blackened ring is not visible in the tubers." (Butler *loc cit*).

Describing what is almost certainly the same disease Smith* says:—

"The foliage becomes prematurely yellow and dies gradually, or wilts suddenly without loss of green"

* Bacteria in Plant Diseases, Vol. III, page 175 (1914).

the stems droop and shrivel when not too woody, and there is usually a decided brown stain in the vascular system in advance of the death of the external parts. The vessels of such stems are filled with enormous number of the small termo-like bacteria which are not sticky and which ooze out of the stem on cross section as a dirty white or brownish white slime. The bacteria pass up and down the stems considerably in advance of the shriveling, and the accompanying brown stain can often be seen through the younger and more translucent stems and petioles.....as long brownish streaks, although the surface of these parts still appears to be normal. In good sized stocky potato plants even when the vascular system is badly diseased (browned and occupied by the bacteria) the exterior of the stem is often green and normal in appearance except the leaves and extreme tips of the growing shoots which are flabby and shriveled. In less woody plants, the branches will be shriveled or flaccid..... In the potato plant the organisms pass down through the vascular system of the stems into the underground parts and cause an internal brown rot of the tubers. This rot of the tuber begins in the vascular system at the stem end and gradually extends to the opposite end by way of the vessels, rotting the tuber grown within and causing the appearance of dusky patches on the smooth surface in advance of any rupture of the superficial cork layer..... In tubers..... cross sections often show the decay pretty closely restricted to the vascular ring, from which there is always a grey white or dirty white bacterial ooze. In yet earlier stages of the disease the brown stain and bacterial decay are found only in the stem end of the tuber (vascular ring) or only in the vascular bundle of the underground stem leading to the tuber, the surface of this rhizome and the whole of the attacked tuber being perfectly sound. On plants attacked with great virulence and very early no tubers are formed. The tubers on plants infected in the middle of the growing season are small and few

and are found at harvest time in all stages of decay. Often on such plants, as first noted by Dr. Halsted, tubers not larger than a pea, together with their rhizome, will be found sound superficially but brown rotted in the vascular ring: in other cases, as already noted, the entire tuber will be sound and only the rhizomes affected,—this through the whole length of its vascular system or only at the end furthest from the tubers. On the other hand when plants are attacked late in the growing season, the tubers are more numerous and larger, and the majority of them, especially if borne on long rhizomes, may escape infection or be diseased only slightly at the stem and when dug. In tubers of this sort, the rot is apt to continue after digging but exceptionally it might, perhaps, remain dormant, or nearly so until the season for planting. In plants attacked by this disease the juice of the stems will be found to have an alkaline reaction to litmus paper if examined microscopically, will be seen to be swarming with bacteria which are very easily cultivated.”

Coleman,* from observation in Mysore, described the symptoms as follows :—

“The disease is readily to be recognised by the sudden wilting of the potato plants in an affected field. By wilting is meant the hanging down loosely of the leaves just as they do when the stem bearing them is cut from the roots. Usually one or two leaves first show the wilting, but within a few days the whole plant wilts down and dries up. If the tubers of an affected plant are cut through, some of them will almost certainly show a brown ring a short distance in from the surface. This ring will be found usually at least, to begin at the part where the tuber is attached to the underground stalk which bears it and to spread from that point around to the other end of the potato. In its first stages, therefore, the ring is not complete but is rather simply indicated

*The Ring Disease of Potatoes—Mysore Department, Agriculture Bulletin (Mycological Section) 1, (1909).

by a more or less distinct brownish stain in the neighbourhood of the point of attachment of the tuber.... The fact that the brown colour appears first at the point of attachment of the tuber indicates that the disease has entered at this point from the stem into the tuber. If a diseased potato be cut and squeezed slightly a series of small creamy white slimy drops are to be seen exuding along the course of the brown ring. Such a drop, if examined under the microscope is found to contain myriads of bacteria shaped like small and very short rods. If a very thin slice of such a potato is examined microscopically these tiny rods are found chiefly in the vessels of the tuber which they plug quite full. These vessels are more or less tube-like structures which help to transport the sap and food materials from one part of the plant to another. In the tuber they form a ring just a short distance in from the outer surface and it is in this ring of vessels that the disease first makes its appearance. From it the disease spreads to the rest of the potato, so that, gradually the whole potato is changed into a rotten mass."

From these descriptions the characteristic appearance of the *bangdi* disease in the plant, in the tuber, and in the stem will be realised,—and also the fact that it is caused by a bacterium which lives in the vascular tissue of both the tuber and the stems. The disease was, when first discovered, supposed to be due to a fungus by Cunningham,* who first examined it. His observations, however, were incorrect, and the bacterium, already sufficiently described, is now proved to be the cause of the disease.

This bacterium appears, according to the various authorities cited, to enter the plant from seed tubers already affected, or from soil which is infected with the organism. In the latter case it has been supposed by Smith that the plants are infected by means of eelworms living in the soil. In the former it is, of course, easy for the bacteria to pass from the diseased

* Scientific Memoirs of Medical Officers of the Army in India, Part X, 1897.

set into the plant and so into the new tubers formed. Smith noticed that it might be passed from plant to plant by the bites of insects such as the Colorado potato beetle, but this kind of inoculation must be very rare in this country, according to Coleman.

Such is the disease which though it had long existed in the Khed area, came into prominence first in the early nineties, and which spread so rapidly as to become a menace to the cultivation within a very few years.

When we first carefully examined the condition in the Khed potato area in February 1917, the *rabi* crop was on the ground, and the first thing that struck the observer was the all but universal occurrence of ring disease. Almost everywhere it was recognised as leading to enormous losses, and though less prevalent in some villages (such as Peth) than in most yet it was present even in these. Often twenty to thirty per cent. of the plants in a plot had died, and we could find instances of as much as seventy or eighty per cent. of what seemed at one time a very promising crop to be lost on account of the disease. The people at that time attributed the occurrence of the disease almost entirely to the use of infected seed, drew our attention to the fact that the disease appeared very often in patches spreading from one centre, and considered that the only way of checking it was the importation, at fairly frequent intervals, of Italian seed from Bombay.

Beyond this we could not at the time go. Since that time we have ascertained many new facts, and we feel we are in a position to recommend measures which will have the effect of materially diminishing the seriousness of the disease.

The most important point in combating this disease was to find the usual means of infection. It had been known since the investigations of Coleman (1909), that diseased seed tubers would produce diseased plants, and, moreover, that infection could also take place through infected soil. But the relative importance of these methods in actual practice

had not been determined and it was absolutely necessary to our work to find out how the disease was most frequently carried from crop to crop. In other words, if soil infection was the chief source of the disease in our fields, it would be necessary to fight the disease by keeping infected fields free from susceptible plants until the bacteria which cause the disease die out. If, on the other hand, the seed was the chief means of infection, careful attention to the seed would be the primary, and might even be the only necessary method of precaution.

The determination of these points was the object of a series of pot experiments in 1917 and 1918,* in which potatoes were grown in fresh river soil in which no infection could have occurred, and infection was introduced in the following ways :—

- (1) by planting potatoes containing ring disease ;
- (2) by mixing pieces of potato attacked by ring disease with the soil ;
- (3) by watering the soil with water in which cut sets of potatoes attacked by ring disease had been allowed to lie for half an hour ;
- (4) by inserting pieces of potato infected with ring disease in the potato sets ;
- (5) by soaking the potato sets in water used to wash potatoes affected with ring-disease ;
- (6) by using, as seed, tubers from a plant affected with ring-disease, but which themselves showed no sign of the disease ;
- (7) by using a knife infected by cutting affected sets, to cut sound potatoes for planting.

Duplicate pots were taken in each case, but the data were consistent throughout, and have results as follows :—

* An account of these experiments was published in the *Agricultural Journal of India*, Vol. XIV, page 388 (1919).

- (1) Where diseased potatoes (eight sets) were planted
- (a) six sets did not germinate ;
 - (b) one set germinated, but began to wither eleven days later, and was completely dead after a week ;
 - (c) one set germinated and grew fairly well. It however produced no tubers, and after ripening the original set was found to be rotten.

(2) Where the soil was infected with fragments of infected potato. Six sets were planted, and all germinated. Seven days later one was wilting. After eleven days two plants were dead and two were wilting. A week later one more was dead, but the other affected plant was making an effort to throw out new buds. It was in vain, however, and seven days after it was dead. At this time (4½ weeks after planting) all were affected and either dead or dying save one plant. This latter remained apparently healthy and matured normally giving three ripe tubers. On cutting these, however, all were found showing signs of ring disease in the tuber. Infection of the soil by fragments of diseased tuber is, therefore, very fatal, and even if the plants do not die, the tubers are very likely to be diseased.

(3) Where the soil was infected by the water in which diseased potatoes had been soaked.

Five sets out of six germinated, but all died of ring disease. They were quite healthy, however, for over three weeks, and then wilted and died in rapid succession. After six weeks all were dead.

This experiment shows the extremely infective character of the water in which diseased sets have been soaked.

(4) Where the sets were infected by the insertion of fragments of diseased tubers.

The results of this method of infection showed it to be by no means so certain or so rapid as those

previously considered. Out of six plants, one died in six weeks, and two more a week later. The remainder (3) ripened and were harvested in due course three months after. Of the tubers produced, those from one plant all showed signs of ring disease, from a second all showed signs except one and in this none could be detected, while in the third no ring disease could be observed in any of the tubers produced.

(5) Where the sets were infected by soaking in the water in which diseased potatoes had been placed.

In this case all the potatoes germinated normally. The first sign of disease was observed twenty-four days later, but the progress was very rapid and all were dead thirty-six days after planting.

(6) Where the sets were from infected plants, but themselves showed no signs of ring disease.

Out of eight such sets planted two died of ring disease five weeks after planting. The remainder were harvested but all the tubers produced showed signs of ring disease. This experiment showed clearly that the potatoes which were obtained from ring-disease affected plants but showed themselves no sign of the disease were unsafe as seed.

(7) Where the sets, though healthy were cut with a knife previously used to cut a potato affected with ring disease.

Fifteen healthy potato sets were planted their only connection with the disease being that the knife used for cutting them had previously been used to cut diseased potatoes. Fourteen sets germinated in due course and in good time. A month later five of them were dead, and gradually all died before maturity except two. These two matured, but all the tubers on them were half rotted with ring disease when they were taken out.

This experiment shows the extreme infectiveness of the disease.

The position is, therefore, clear. The ring disease is extremely infectious and may be carried by diseased sets or by anything which has been in contact with them. The soil may carry the disease whether it has been infected by diseased tubers, by water in which diseased tubers have been washed, or by remnants of diseased potato plants remaining in the soil. And even the knives used for cutting a few diseased tubers may infect a large part of a crop, when the seed is otherwise of good quality. This last fact is beginning now to be realised by the cultivators, and we have introduced a system of sterilizing the knives used to cut diseased potatoes, among the more advanced cultivators of the Poona potato tract.

Perhaps the chief interest, however, lies in the infection through the soil, and the length of time during which the bacteria are capable of living there, and infecting the following crop. It is obvious that if the organism is capable of making soil infective for a long period potato cultivation is doomed in these districts. We have hence made experiments to ascertain how soon potatoes can again be safely grown after the soil is thoroughly infected with the disease.

Pots were taken in which all the plants had died through soil infection with water in which diseased sets had been soaked but from which all remnants of diseased plants were removed. Then new healthy sets were planted (1) immediately, (2) after two to three months and (3) after about six months. In the meantime the soil was allowed to stand without cultivation.

Where healthy potato sets were planted immediately after the removal of the previous (diseased) crop, all the plants were affected; out of four plants one died within three weeks of planting, another within four weeks while a month later a third was dead. The fourth was attacked, but was able

to throw out new shoots and came to maturity. No tubers were however formed. In this case, therefore, all plants were affected.

The soil from which the last crop was harvested was then allowed to stand for two and a half months (November 1st to January 18th) and then replanted. Four plants were obtained. Three remained healthy throughout, produced good tubers which showed no sign of ring disease. The fourth plant began to droop after three months and was then dug up. Of the three potatoes produced by this plant, two were apparently healthy, but the third was undoubtedly attacked with ring disease.

The same pot was again sown a week later (eleven months after the original infection), the plants matured healthily and the tubers showed no sign of ring disease.

In a further experiment, the soil was thoroughly infected with diseased material and healthy sets planted immediately. All died in due course, and then, after removal of the plant residues, the soil was allowed to stand for five months without a crop (August 18th to January 18th). It was then planted with healthy sets. Under these circumstances all the sets germinated perfectly, grew healthily and ripened normally. No tuber or plant showed any sign of ring disease.

As this matter appeared very important the experiment was repeated with not less than nine pots in all of which the soil was thoroughly infected as shown by the complete loss of the previous crop. In each case, after removal of the plants, the soil was allowed to stand for 6½ months (September 11th to March 27th) and then planted with healthy sets. All germinated and no sign of ring disease was found throughout growth. None of the tubers produced were infected with ring disease.

In summary, we may say that these experiments confirm previous results as to the conveyance of the ring disease of potatoes from crop to crop both through the seed and the

soil. They show the extremely infectious character of the disease in that not only the seed but also everything which has been in contact with it, even the knife by which diseased sets have been cut, are capable of conveying the disease to a healthy tuber and hence to a healthy plant.

The infection does not, however, live long in the soil in a virulent enough condition to affect new plants. After two and a half months the infectiveness was reduced by at least seventy-five per cent. After five to six and a half months the infectiveness of the soil has disappeared.* It would appear clear, therefore, that if land is kept free from potato plants, or other plants, like tobacco, capable of carrying the disease, for six months, the danger of infection through the soil is very small, if, indeed, it is not entirely eliminated. Inasmuch as the potato crop, usually reaped in February or March, is never planted on the same land until October or November, and the crop reaped in September or October is never planted on the same land until the following June, it would appear that the danger of infection through the soil under Deccan conditions is small, if the diseased plants are carefully removed in each crop. This agrees with practical experience and enables attention to be focussed on the provision of disease-free seed as the main line of the attack on this very fatal disease.

Disease free seed did not exist in the Bombay Presidency when these experiments were initiated: whenever seed was obtained from, it was infected to a greater or less extent. This being the case, there were only two methods open to us to secure it. The first of these was that of continually renewing the seed used by import from the country of origin,—in this case Italy. The other was by selecting the apparently healthy potatoes from any supply of seed, and growing them for several generations with strict field elimination of all infected plants in each generation.

* As against this, Butler reports that five years are considered as necessary in America to remove the infectiveness of the bacterial wilt of tobacco caused by the same organism.

The first of these methods was that adopted by the cultivators twenty years ago and since that time Italian white round potatoes, at that time imported for food, were found to be a very suitable variety for growing in the Deccan, where the thin skinned ordinary potatoes of northern India have never flourished. They were, moreover, found to be almost if not absolutely free from the ring disease, and hence gave security for several generations of crop. It became, therefore, the custom among good cultivators to obtain new Italian seed every fourth year or so, and a regular trade in seed potatoes developed. Then came the war in 1914, and the trade stopped. No more potato seed could be obtained and the crop grown rapidly deteriorated, because the seed became more and more infected.

We may draw attention, however, to the fact that judging from our experience in 1920 the seed from Italy is not *entirely* free from the disease. Seed obtained in January 1920 was planted by a number of cultivators on land which had not borne potatoes for several years. In cutting the potatoes, it was reported to us that tubers affected with ring disease had been found, and in the fields themselves we saw a few plants only which had undoubtedly died of this affection. The incidence of the attack was not more than 0.05 per cent. and so the affection in the seed must have been very small. But it is there, and it must not be considered that the use of Italian seed forms a means of completely guarding against it under the very favourable conditions which prevail here for its development.*

In the absence of fresh exotic practically disease free seed, it became necessary to see whether good seed could not be obtained locally by selection alone from existing seed, or by selection and growing of the seed, with field elimination

* It has been suggested that potato seed imported from Italy is resistant to ring disease and that it loses its resisting power after having been grown in the Deccan (*vide* Proceedings of Mycological Conference, Pusa, 1919). There is, however, no evidence that this is the case, and we have never had the slightest difficulty in infecting fresh Italian seed and, as a matter of fact, it is exceedingly susceptible.

of diseased plants—and a good deal has been done in these directions.

In the first place, it was important to see what can be done by mere careful selection of the seed. Ring disease, though the work of an internal parasite, can be detected, though with some difficulty, without cutting the tuber. The signs of attack, when this latter is in an advanced stage, are very marked. The eyes become dark in colour, have a “drawn-in” appearance, and drops of slimy liquid exude from them. Hence the name of “sore eyes” given to the disease in some parts of the world. But long before the disease reaches this condition its presence in the tuber can be detected by the following signs:—

(a) The surface of the tuber just round the eyes takes on a peculiar darkened appearance. This may be noticed all over the tubers or round certain eyes only, and is specially seen round the eye at the end of the tuber furthest from the stem. This darkening is not noticed except on careful observation and many even among the cultivators have never seen it. But we have succeeded in training women employed in sorting seed potatoes, to recognise it at once and easily.

(b) The scale leaves in the eyes turn dark and appear dry. This again only appears to certain eyes, and demands nice observation unless attention is specially concentrated upon it.

(c) The eyes as a whole have a drawn in appearance, but this appears only to those eyes in the portion of the tuber where the vascular tissue is affected.

(d) The skin of the potato loses its fresh appearance and becomes dull.

Using all these methods of examination, a large portion of the ring diseased potatoes, can be eliminated. In one case where sorting was done very carefully in a badly infected lot

of tubers, out of *one ton* of potatoes the following quantities were picked out :—

(1) By sorting one month after harvesting—813 lbs. (36 per cent.).

(2) By second sorting after storage and four months after harvesting—96 lbs. (4 per cent.).

After this, on cutting the potatoes for planting 14 lbs. of potatoes were found to be affected with ring disease and not to have been eliminated by the various sortings, or 0·6 per cent. If this were all, it would appear that selection only was capable of almost eliminating the ring disease. But, in the field itself, on growing, a further large number of plants died amounting to 13 per cent. It is not certain that all these died of ring disease, but a large proportion certainly did so. And, as a result, it is obvious that simple selection by examining the seed for the characters mentioned above, or even examination of the cut sets is not sufficient to avoid attack in the field. There are evidently a large number of potatoes which are so slightly affected that they are not detected even when planting, and yet which are capable of leading to the death of plants in the field, or (as we shall see) the perpetuation of the disease in the next generation. While, therefore, selection of seed from an infected lot will reduce the percentage of attack, the disease cannot be eliminated by this means. Probably the best that can be done by this method is to reduce the attack of ring disease to an extent indicated by the following figures, reported at Belgaum by the District Agricultural Overseer in 1918.

	Yield per acre.	Percentage of ring disease and rotting.
	lbs.	Per cent.
Dharwar Seed ..	4,200	50
Poona bazar Seed ..	5,600	30
Kheda <i>Selected Seed</i> ..	8,400	5

As mere selection was not sufficient, and as importation from Italy was impossible, it only remained to see whether ring disease could be got rid of by gradual elimination by taking crop after crop, selecting the potatoes carefully each time for seed, and strictly removing all affected plants in the field. This has been done, and by this means we have obtained a stock of *pedigree seed* in five generations which is almost though still not quite, free from ring disease. The course of the production of these pedigree seed potatoes is shown in the following statements.

1. The original seed was taken from a lot of potatoes at Peth in 1917. The crop was reaped in the first week of February, and after fumigation a month later, one ton was taken out of a total of eight tons as the basis for the experiments. Careful selection was done at once, and 813 lbs. were at once rejected (36 per cent.) being obviously attacked with ring or other diseases. The rest was stored till June, and then was reselected when 96 pounds more (4 per cent.) were eliminated. On cutting before planting (on June 7th) 14 pounds (0·6 per cent.) more were found to be attacked and were rejected. All precautions were taken against infection of the remaining seed by sterilising the knives used for cutting the sets, in boiling water after every suspicious potato had been cut, and by insisting on all labourers who handled them washing their hands with hot water and soap before touching other potatoes.

Thus before planting 40·6 per cent. of the potatoes were rejected. In the field 10,472 plants died out of 80,000 or 13 per cent. The sets were planted twelve inches apart, so as to leave plenty of space for growth. All the deaths were not due to ring disease. Many dying from *rhizoctonia* blight and other diseases. The remainder were reaped on September 8th, 1917.

2. The seed so obtained was fumigated three weeks later and selected as before. From 3,000 pounds of potatoes we obtained:—

(a) First selection—217 lbs. of ring-diseased potatoes (7·2 per cent.).

(b) Second selection before and at planting 67 lbs. of ring-diseased potatoes (2·2 per cent.).

One ton of seed potatoes were planted (at Chakan) on December 15th, and from this 5,730 plants died or 7 per cent. The remainder were harvested on March 20th, 1918.

3. The seed so obtained was fumigated and then kept till the following October. After fumigation, the ring-diseased potatoes were removed amounting to 67 lbs. out of 3,000 lbs. or 2·2 per cent. A second sorting in July was made giving 10 lbs. more of rejection (0·3 per cent.) and a third sorting at the beginning of October gave 19 lbs. (0·6 per cent.) or a total of 106 lbs. or 3·1 per cent. During the storage period there was a good deal of dry rot (*fusarium*) but this was not taken into consideration in the present case.

One ton of seed potatoes were planted (October 3, 1918) at Awasari and at the time of planting 6 lbs. (0·3 per cent.) of the potatoes were rejected. During the growing period 2,722 plants or 3·4 per cent. died and were removed. Harvesting took place on January 14th, 1919.

4. The seed so obtained was fumigated, sorted, bagged and stored till June 1919. At the first sorting 6 lbs. (0·2 per cent.) were rejected out of 3,000 lbs. of tubers, on account of ring disease at the second selection 20 lbs. more (0·7 per cent.) were removed and at the time of planting 4 lbs. more (0·1 per cent.) were taken out. The total percentage removed between harvest and replanting was 1·0 per cent.

One ton were again planted (at Peth) in June. Owing to an unsuitable field being chosen many plants died of rhizoctonia blight. But only 196 plants (out of 80,000) or

0.24 per cent. were definitely killed by ring disease. The crop was harvested in September.

5. Similar figures for the next crop are as follows:—

(a) 3,000 lbs. of seed on all sortings up to planting time gave 26 pounds of ring-diseased potato (0.9 per cent.).

(b) one ton of seed, at the time of planting at Pargaon, gave 13 ring-diseased potatoes (about 3 lbs. or 0.1 per cent.).

(c) During growth between November 1919 and February 1920, 46 plants died from ring disease or 0.1 per cent. As we write, the plants are in store for planting in June 1920.

The whole history can be summarised in the following table* :—

Generation.	Disease on 1st sorting.	Disease on 2nd sorting.	Disease on 3rd sorting.	Disease at time of planting.	Ring disease in field.	Total, Ring disease.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
I ..	36	4	....	0.6	13	53.6
II ..	7.2	2.2†	....	....	7	16.4
III ..	2.2	0.3	0.6	0.3	3.4	6.8
IV ..	0.2	0.7	....	0.1	0.2	1.2
V ..	-	0.9	....	0.1	0.1	1.1

* In the first crop the rejections include all diseased potatoes: in the later ones only ring-diseased potatoes or plants are considered.

† All rejections up to planting.

In five generations, therefore, the amount of attack with ring disease has been reduced to a very small proportion and this can doubtless be carried further. And this method therefore reveals clearly the way in which a stock of acclimatised seed can be maintained which is not seriously affected with ring disease. It is only necessary to grow the stock under conditions of rigid elimination of all affected potatoes and of all affected plants at every stage, and the fear of the disease will disappear. The seed so produced will be far cheaper than that imported from Italy, and will be independent of any failure of the latter supply. It seems, in

fact, that the maintenance of a stock of pedigree seed is the only practicable way by which ring disease now rampant in our potato areas, can be gradually eliminated, or at any rate, kept under control.

The principal points of practical importance which emerge from this discussion of our experiments on ring disease are as follows :—

1. Under the conditions which prevail in the Poona district and probably also in other parts of Western India, ring disease is almost exclusively carried by seed. Although the soil may be a source of infection, yet the disease quickly dies out in it, and six months after infection it ceases to be a serious source of disease.

2. Every diseased tuber or diseased plant is, however, a very powerful source of infection as the bacteria are extremely virulent. Hence every plant which dies in the field should be immediately removed, together with all tubers and roots attached to it, and buried deep. After harvesting careful selection of the tubers should be made among all that may be used for seed and the affected potatoes sold at once. Fresh selection should be done before seed is taken to the field for planting.

3. At planting, the sets, on being cut, should be carefully examined for the signs of disease, and all diseased sets rigidly excluded. The man who is cutting and examining the sets should be provided with boiling water and the knife used for cutting a diseased set should be sterilised in this boiling water before being used to cut others. This method is now actually adopted by some of the more advanced cultivators in the Khed potato tract.

4. The only practicable way we have found of eliminating the disease is by the use of disease-free seed, whether from abroad, or by obtaining pedigree seed by strict selection, and elimination of disease during a number of generations. We have succeeded in reducing the incidence of the disease

from 53.6 per cent.* to 1.1 per cent.† in five generations. This method gives a system whereby cheaper seed can be obtained than that bought from Italy and at the same time makes us independent of international troubles which may again at any time prevent us from being able to get seed from abroad, as has happened from 1915-1920.

5. It has been possible for the agricultural department with the assistance of the cultivators to maintain a stock of from one ton upward of such pedigree seed : multiplication beyond this point is the work of an agency working on a commercial basis. It is certain that the people will pay a good price for seed in which they have confidence.

VII.—OTHER DISEASES FOUND IN THE SEED.

BY S. D. NAGPURKAR, B.AG. AND G. S. KULKARNI, B.AG.

Our investigations of other diseases found in the seed in Western India, which may spread to the plants in the field and hence cause loss and low yield generally, have been of a somewhat casual character, but it will be well to put on record what has been noticed,—as some of these diseases are of very great importance and demand early and thorough investigation. The diseases which we have noticed in the seed in Western India are as follows :—

1. Dry rot caused by various species of *Fusarium*, and especially by *Fusarium trichothecioides* and by *Fusarium oxysporum*. This is universal and very prevalent.

2. *Rhizoctonia blight*.—Of this *Rhizoctonia destruens* is very common on potatoes in store, and *Rhizoctonia solani* is also found.

3. *Spongospora subterranea*, or *kuzali* found only in hill-grown potatoes, chiefly at or Mahableswar but also occurring in the Nilgiri potatoes.

4. Potato eelworm (*devi*) which is fairly common in the *kharif* grown crop of potatoes, but can hardly be called very serious pest here, except perhaps at Karachi.

* All diseases

† Ring disease only.

A Dry Rot of Potato Tubers.

Among all the diseases and troubles of potato storage, dry rot is (if we exclude the potato moth) the worst and most generally widespread in Western India. It is known to be liable to invade stored potatoes every where in the world, if they are kept under any but very cool conditions,—and cool conditions are impossible here. The most usual form of the attack is a softening of the skin at one point (generally the stem end of the tuber) with a slight depression. The skin may or may not split at this point. If it does, the hole so produced enlarges and the potato is gradually eaten up by the fungus leaving a brown residue. If it does not the potato gradually shrivels and ultimately remains as shrivelled mass of hard brown matter. These characteristics are associated with the name '*khokha*' among the cultivators in the Poona district. But the tuber which has been attacked is often also affected by bacteria which convert the diseased potato into a slimy wet mass of rottenness. There are, however, many parasites which produce ultimately this last condition and it is very difficult to state in any one case what is the primary cause of the rotting.

In the case of the *khokha* or dry rot, occurring in its typical forms, there is no difficulty in identifying it, and it occurs in every large sample of potatoes we have come across in India. To ascertain the extent to which this and other rots were contained in actual commercial samples of potatoes of different provenance, a bag of potatoes from six of the chief producing centres in India was examined in January 1918, and the potatoes then stored for two months at the usual temperature in Poona. The results of these observations are as follows :—

1. *Mettapalayam potatoes*.—These potatoes, though marketed at Mettapalayam are grown in the Nilgiris, and are hence produced under fairly temperate conditions at a considerable elevation—4,000 feet and upward.

The amount of potatoes damaged with various attacks is large, as much as 22 per cent. being rejected. In this lot dry rot was especially pronounced, some of the tubers being completely eaten up by the fungus. Many tubers were shrivelled and intact showing the dry rot fungus only. But in a good many tubers the outer covering was broken, and bacteria and moulds had entered and a soft wet rot was the result.

Some examples of *Spongospora* or potato scab (*khuzali*) were noted in these potatoes. This seems peculiar to potatoes grown in the hilly districts.

On storage in bags at the temperature in Poona in January and February (65°F. to 85°F.) the rotting rapidly increased chiefly due to 'dry rot' fungus (at any rate at the beginning) until after 51 days, 90 per cent. of the potatoes were rotten either with simple dry rot or more frequently with the soft wet rots which follow it.

2. *Kalka potatoes*.—These potatoes, again, though marketed at Kalka, are chiefly grown in the Simla hills, and are hence produced under fairly temperate conditions at 2,000 feet elevation and upward.

The amount of potatoes found damaged with various rots in the commercial lot amounted to 15 per cent. The chief form of rotting present was 'wet rot', but the original cause of the damage in most cases appeared to be the 'dry rot' fungus. In the partially damaged potatoes, most of the tubers showed the characteristic sunken wrinkled spots of this disease.

A few potatoes showed signs of damage by eelworms.

After 50 days in bags at the temperature of Poona in January and February (see above) fifty per cent. of the stock had become wholly or partially rotten. By the middle of March only 19 per cent. of the original potatoes were still good, the dry rot fungus being the original cause of damage in most cases.

3. *Meerut Potatoes*.—These potatoes are marketed at Meerut in the United Provinces, but we do not know exactly where they are grown. They showed only three per cent. of partly or wholly rotten potatoes when obtained but among these there were many potatoes attacked by the dry rot fungus and also some by ring disease. The chief rot was undoubtedly 'dry rot'. In 50 days, thirty per cent. had become wholly or partly rotten, chiefly still with the dry rot fungus.

4. *Bangalore Potatoes*.—These potatoes are grown on the Mysore plateau at an elevation ranging from 2,000 feet to about 3,500 feet above sea level. 12 per cent. of the tubers were wholly or partially damaged on receipt and although the rot caused by ring disease was found, yet the chief cause of damage again was the dry rot fungus. Fifty days later, fifty-five per cent. of the potatoes were wholly or partly rotten in Poona, in January and February.

5. *Karachi Potatoes*.—These are grown in the neighbourhood of Karachi in the tract of intensive cultivation within a few miles of that city. Though there was a good deal of dry rot in the potatoes as bought, the characteristic attack in this case was a large amount of eelworm. Nine per cent. of the potatoes were partially or wholly rotten. The 'dry rot' and its sequels, the various forms of wet rotting, kept increasing on storage, and 25 per cent. more potatoes were wholly rotten or partially damaged after fifty days of storage.

6. *Saugor Potatoes*.—The neighbourhood of Saugor in the Central Provinces is a great place for growing *rabi* potatoes, which are then sent to Bombay. The usual dry rot attack was found and its sequels. No ring-disease potatoes were noticed, but there was a considerable amount of rotting due to moth attack. One eelworm attacked potato occurred. The amount damaged on purchase amounted to 6½ per cent.

On keeping, the attack due to dry rot fungus developed and ten per cent. additional potatoes were lost in fifty days.

Pupae of moths were also found. These potatoes have kept better than any of the other lots, examined. They are all Italian white round potatoes produced from Poona seed.

7. *Khed (Poona) Potatoes*.—Potatoes in one of the best village stores in the Poona district were examined one month after being put into storage. The quantity involved was fifty tons, and all these were carefully sorted. From this quantity five tons were rejected on account of attack by dry rot and its sequels. They were fumigated and bagged, and kept in store at a temperature below 88°F. After three months in the store they were again sorted with the following results :—

	lbs.
Rejected on account of ring disease ..	407
Rejected on account of <i>fusarium</i> in its various forms ..	1,960
Rejected on account of 'heat rot' ..	178
Rejected on account of unknown rots ..	840
Total ..	3,385

Thus of the total rotting, fifty-eight per cent. is due to the dry rot fungus (*fusarium*).

From this account of actual observations of potatoes on the market, it will be seen how far the 'dry rot' dominates the situation so far as keeping potatoes for seed is concerned, provided (as we shall see later) the temperature is kept within the permissible limit. We have now to consider how far the dry rot damages the tubers for seed purposes.

The dry rot of potato tubers, it seems now definitely to be proved, is caused by a species of fungus belonging to the genus *fusarium*, and the latest information available* seems to indicate that several species may cause the damage under different conditions, and that these also may cause a

* Link—Botanical Gazette, Vol. 62, page 169 (1917).

wilt of the potato plant in the field. Two species have been identified here,* and they are the same which appear to do the greatest damage in America. As far as is known potatoes most usually become infected through the soil. The fungus enters the plant through the roots, thence goes into the underground stems, and finally into the tubers. How far other methods of infection prevail is doubtful and so experiments were made in the following direction with Italian white round potatoes at Poona.

A.—Do potatoes attacked by dry rot (*fusarium*) infect those with which they are stored? The answer to this question has been given by McAlpine† and Link (loc cit.) in certain cases. The former found that when the skin of a tuber was broken infection was generally easy from a potato already infected and that in the case of very young potatoes where the skin was unbroken infection could still take place: the latter confirmed the first of these observations as regards both of the species of *fusarium* which are apparently concerned in the present case.

With the contention that dry rot infection can be carried from tuber to tuber by infection through cut or broken surfaces we are in agreement, and it is well known to the cultivators in the Khed potato tract. When they find a potato which is damaged at the stem end, they consider that such a potato is certain to decay in storage.

But the infection of mature potatoes with unbroken skin, has not been successful with us with Italian white round potatoes. In the case quoted McAlpine only obtained such infection with very young potatoes, and it is quite possible that the extent to which it takes place depends largely if not entirely on the thinness and delicacy of the skin of the potato tuber. The Italian white round potato with which we have worked

* *Fusarium trichothecioides* and *Fusarium oxysporum*.

† Potato Diseases in Australia, Melbourne, 1911.

has an exceptionally thick skin and it shows much slower deterioration in storage than any others grown in India. The potatoes are in fact preferred by the cultivators not so much because they give a bigger yield in the field, but because there is less loss in storage owing to dry rot and its sequels. At any rate all the experiments in which we have attempted to infect healthy unbroken mature tubers of this variety by storage with potatoes sttacked with dry rot have failed. Whether this will apply equally to the thinner skinned varieties of northern and southern India we do not know.

B.—Do tubers, infected with *fusarium* and used as seed give rise to tubers also infected and likely to rot.

On this point there does not seem any definite information to be obtained from other authorities, but the matter is one of great importance in our areas, because (1) the people have noticed that potatoes slightly attacked with dry rot germinate more quickly than perfectly healthy tubers, which is supposed to be a great advantage and (2) the whole question of the maintenance of a satisfactory seed supply for planting is affected by the question as to whether we must necessarily reject seed potatoes which show any signs of dry rot (*khokha*) attack.

It has not, we believe, been noticed hitherto that potatoes slightly attacked with *fusarium* in the form of dry rot, do germinate quicker than ordinary sets. This was often, as already stated, mentioned to us by the people, but definite experiments were wanting. The following are the details of a recent experiment on the subject.

One hundred clean potatoes, and one hundred in which the dry rot was just developing and where the affected portion was one inch in diameter were taken, and germinated in soil. The number which had germinated after two weeks and after

three weeks was as follows. In each case the seed was four months old.

	Clean seed Per cent.	Fusarium seed. Per cent
(1) Germinated after two weeks..	50	89
(2) Germinated after three weeks.	80	97

The result agrees, therefore, with the contention of the cultivators.

As to whether seed potatoes slightly attacked with fusarium do lead to attack in the tuber, we have the following experiments.

1. The potatoes were grown (in 1917) in pots containing fresh river soil which had never previously borne this crop. Four sets from a slightly attacked tuber, in which the eyes appeared still quite healthy were planted. The plants grew healthily, and twelve mature potatoes were harvested, all being perfectly healthy at the time of harvest. After 15 days storage three of the largest potatoes showed signs of dry rot, and a month later four more were also affected. Two more were attacked after $2\frac{1}{2}$ months. The others remained free from disease for over three months. Thus 75 per cent. of the tubers produced from *fusarium* affected seed were attacked by dry rot during a storage of three months. Healthy potatoes in the same soil as above showed no sign of *fusarium* attack in storage.

2. A similar experiment was made in 1919, when eight sets like those in experiment No. 1 were planted and all grew healthily. Thirty-two potatoes were recovered all being healthy at the time of harvest. Out of these, nine were affected with fusarium after a month in storage, or nearly thirty per cent. of the total.

Other similar experiments gave similar results and it seems clear, therefore, that seed potatoes attacked with dry rot, while they may yield apparently healthy tubers

at harvest, yet give a very large probability of being attacked with *fusarium* at a later stage.

C.—Do potatoes become affected through the soil, or in other words does an infected soil produce tubers likely to rot? It has generally been considered that infection from the soil is the usual method, and the following experiment in pots containing river soil was designed to show what would happen with the variety in use in the Deccan. The soil was infected by incorporating thoroughly with it scrapings from potatoes suffering from dry rot. Healthy sets were planted, and at harvesting the tubers (8) collected were *all* healthy. Twenty days later one showed signs of dry rot and after three months seven tubers were diseased or 88 per cent. It will thus be seen that infecting of the plant through the soil, immediately after infection, is fairly certain.

To see whether the infection in the soil would last for some time, the pots used in the last experiment were allowed to stand for three months and were then again planted with healthy sets. These grew well, and the plants remained healthy up to maturity. At harvesting all the potatoes were sound. Twenty days later one potato was affected with dry rot. Two months after harvest, all were diseased with *fusarium*. It is evident that the soil remains completely infective for three months.

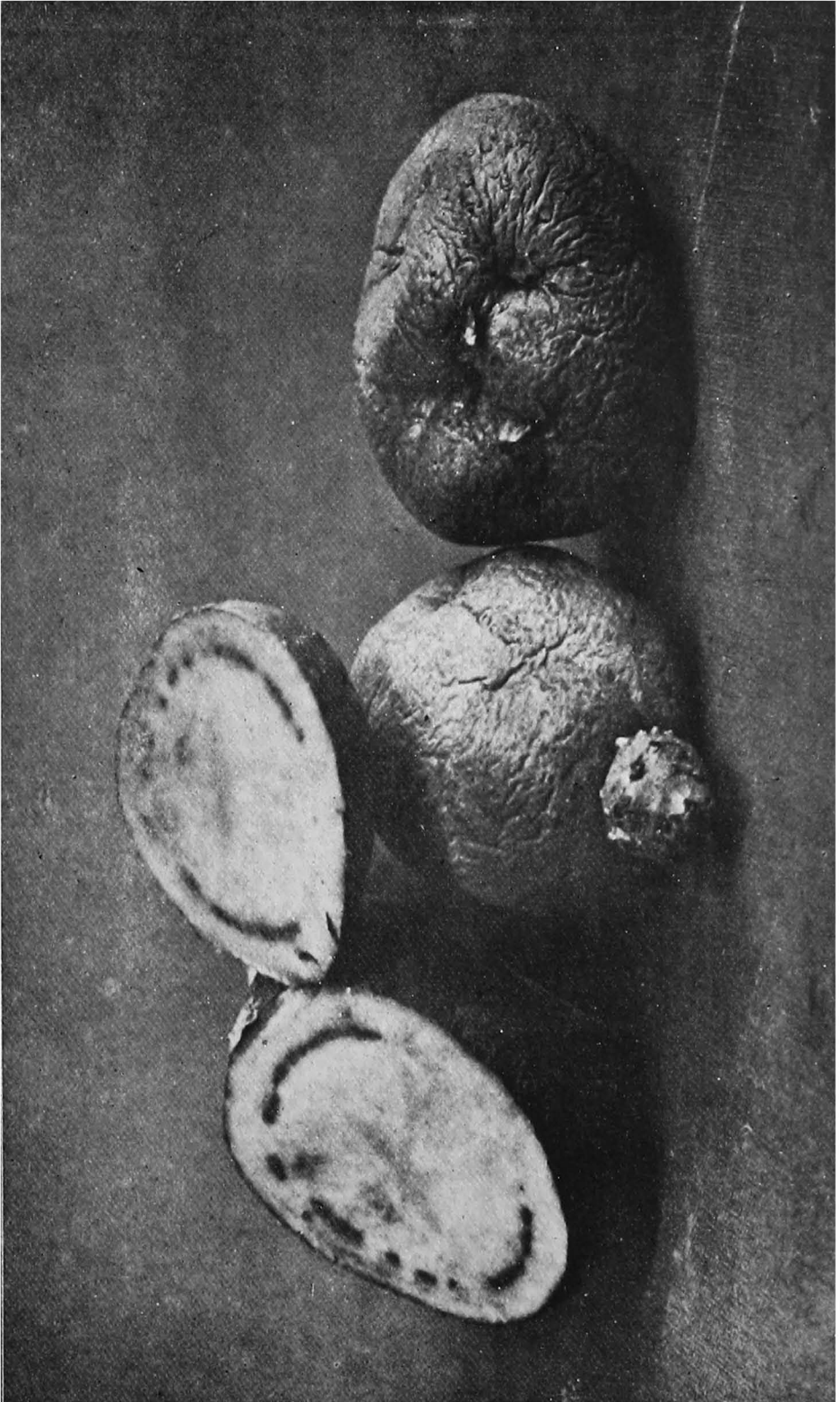
Another infected pot was kept for eight months after removal of the first crop, and was then again planted. All the potatoes were healthy at harvest, and remained healthy for three months in storage.

While, therefore, this experiment cannot be regarded as conclusive, yet it would indicate that infected soil will produce disease in tubers grown upon it, that the soil remains infective for three months in the dry season when no crop is growing, but that after eight months (in the dry weather) without crop, the chance of infection is very much reduced.

Wilt Disease Caused by Fusarium.—It seems clear that the rot in storage which we have now discussed is not the only way in which one or other of the species of *fusarium* may attack potatoes, and that one of the fairly frequent wilts of the crop in the field is caused by a fungus belonging to this genus. Exactly what the relationship of the rotting of the tubers to wilt in the field may be, is not yet known, but such a wilt has been observed in America and in Australia as well as here, and under the name of 'brown ring' or 'wilt disease' has been frequently described. We did not notice it here in the Deccan until recently, but the presence of a number of plants which were wilting in the fields, with a brown ring in the tubers and yet which were not affected with the bacterial ring disease already described, led us to discovery that the *fusarium* wilt of potatoes also exists here.

This fact accounts for many of the contradictory reports which we have received about crops grown with seed which we have supplied. In one case, seed was supplied and was reported to have been badly affected with ring disease. This was quite incomprehensible, especially when it was stated that eighty per cent. of a crop had died. The rings in the tubers did not however show the characteristic of true ring disease, and it now seems certain that they were produced by *fusarium* in the soil. Another recent case occurred with fresh Italian seed, planted in land which had never borne a crop of potatoes before. A number of the plants died, with a brown ring in the tubers, which under special examination by the Economic Botanist to Government (Dr. Burns) were found to be affected with a species of *fusarium*.

We have done little with this disease except to note its occurrence at the agricultural college farm, Poona (March 1919) and at Chakan and several other villages in the Khed potato tract. But we have kept potatoes from plants which



Fusarium Wilt in Potato Tubers.

have died in the last stage of life and which contained a brown ring. These have been planted, in *fusarium*-free soil, have grown to maturity, and have yielded tubers which became damaged with dry rot. But of the relationship of the two forms we at present know nothing. We have planted potatoes affected with dry rot in several stages, and we have planted healthy sets in infected soil, but so far we have not succeeded in producing the *fusarium* wilt with certainty by any method. Whether the *fusarium* connected with this is a different one from that which is usually found in the dry rot here is uncertain, but it appears unlikely in view of the work of Link (loc. cit.) and others. The whole question of the relationship of the two forms requires careful and thorough investigation at an early date.

Summarising with regard to the dry rot fungus (*fusarium*) of potato tubers and the very similar if not identical fungus which causes wilt in the field we may note as follows :—

(1) Dry rot forms by far the dominant disease of stored potatoes in India, seed potatoes from every part of the country being badly affected. In some cases, the amount present is so great that storage in Poona in the cold weather for two months at about 80°F. means the loss of over 80 per cent. of the stored potatoes.

(2) The Italian white round potato, grown in Poona and on the Deccan generally, does not rot so easily in store with this fungus as the thinner skinned kidney varieties grown in the Nilgiris, the Himalayas and North India generally.

(3) While potatoes with broken skin are infected in the store there is no evidence that mature potatoes with unbroken skin, of the Italian white round variety can be so infected, all our experiments to secure such infection have failed.

(4) *Fusarium*-infected tubers when used as seed give tubers which while apparently healthy at harvest rapidly become damaged by dry rot, and hence rapidly decay in storage.

(5) Tubers grown in infected soil, rapidly decay on storage. The soil remains infective for three months at least. After eight months, in one experiment, infection was not obtained but this cannot be regarded as conclusive.

(6) With these results, the use of infected seed, however slight the infection may be, must be regarded as perpetuating the disease, though it may not apparently give a lower yield or unhealthy plants in the field. To obtain good seed, the potatoes must also be planted in soil which has not recently borne a crop liable to this disease. Eight months is the minimum time required for soil to free itself from infection and it may need much more.

(7) *Fusarium* wilt, leading to dying of the plants in the field also occurs in the Deccan area. Its relationship to the dry rot which is so common is not known, but when a tuber from a wilted plant is grown, the tubers which are produced are rapidly attacked by what is apparently ordinary dry rot, in storage.

B.—*Rhizoctonia* Blight of Potatoes.

If any one visited the Khed potato tract during the time of *kharif* or rains crop is growing, and saw the very large mortality caused by the *rhizoctonia* blight in many cases, he would be inclined to consider it as the worst of the diseases affecting the potato plant in this part of Western India. The field characteristics of the disease are as follows. The plant, apparently in good condition, begins to wilt without apparent reason. The wilting commences at the lower branches, but quickly spreads until after from six

to eight days the whole of the leaves are hanging down and the plant is withering. On pulling up the plant, the lower portion of the stem is found rotten and its fibres can be easily separated from one another with the fingers. As a rule this part of the stem and root are covered with a white fungus mycelium, among which there often exist a number of brown knots or sclerotia. These fungus mycelia often spread over the rootlets and tubers, and also through the soil to adjoining plants. This last occurrence was noticed with special frequency in 1919 at Peth. The people call the disease ' *huri* '.

The disease is caused by a fungus or group of fungi well known throughout the world to cause both a wilt of the potato plant in the field and a rot of the potato tuber in storage. In India, the matter of these fungi has been closely investigated by Shaw and Ajrekar, and the mode of attack has been described by them as follows :—

“As already mentioned the potato is liable to disease owing to this fungus. In Bihar the parasite has appeared chiefly as a rot of stored potato, but in the vicinity of Poona it is a frequent cause of trouble to the growing crop. The mode of attack is exactly similar to that observed in the betel vine, the portion of the stem at the ground level, and the subterranean parts of the plant becoming covered with a web of hyphae with sclerotia. This is followed by the rotting of these parts and by the drying and browning of the leaves. The attack is usually late, about six weeks after the planting of the sets. The tubers from diseased plants are apparently sound, although smaller than those from healthy plants, but cases have been found in which apparently sound tubers from diseased plants have been infected with the mycelium through their attachment to the parent stem. The experience with stored potatoes in Bihar shows that tubers from a diseased crop are probably infected with the fungus. The use of a wash of corrosive

sublimate, combined with proper precautions in storage, would certainly go far towards lessening the disease in store.

“Inoculations of potato tubers were uniformly successful when the infection was made upon the cut surface of a tuber. In unwounded tubers although the fungus spread over the surface of the tuber, the external corky covering was sufficient in many cases to prevent penetration. Sometimes, however, penetration took place through the eyes, or even through the lenticels. The same results were obtained whether the fungus used for inoculation has been isolated from a diseased potato or from the betel vine.”*

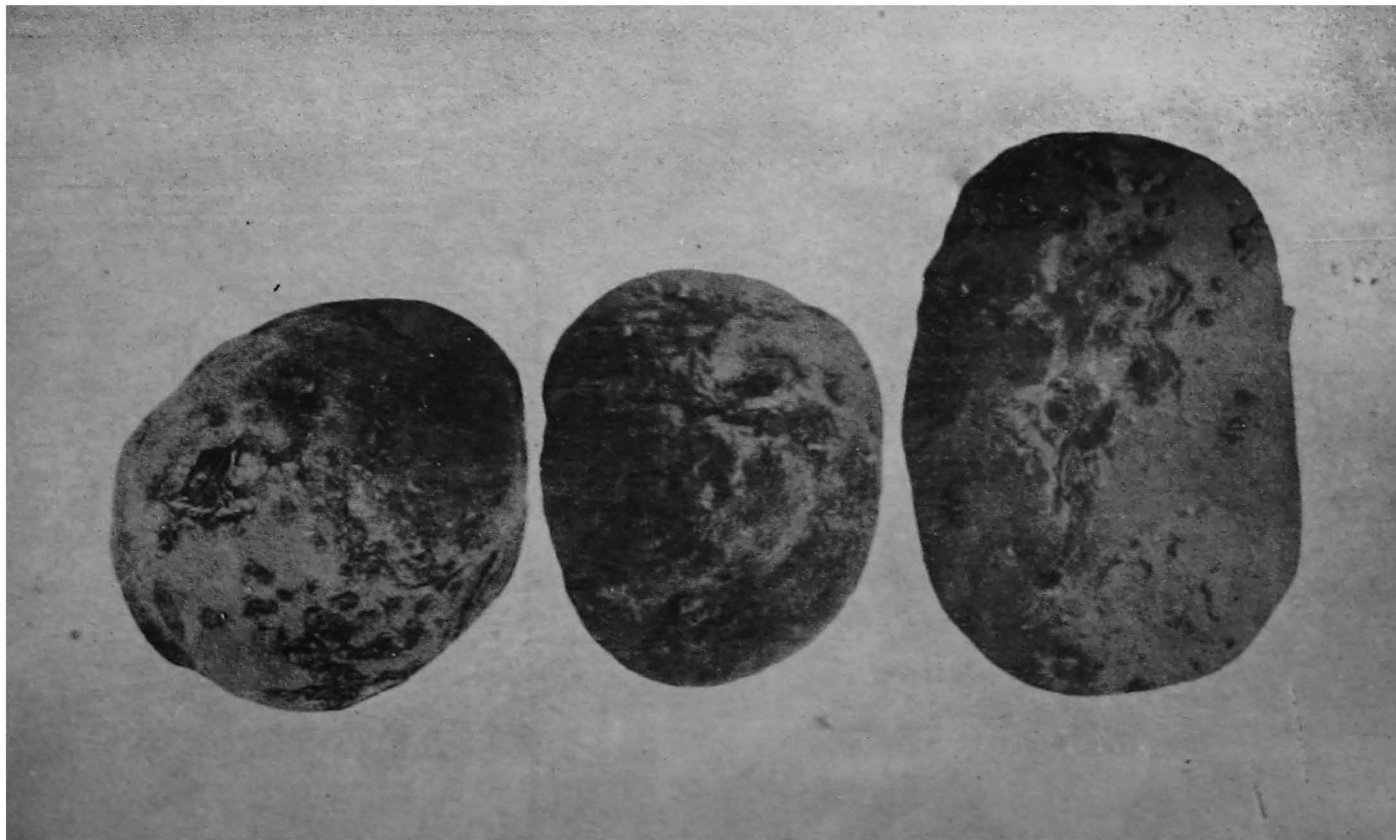
As noted by the above authors, rhizoctonia not only caused a very serious wilt in the field, but also a rot in storage. This occurs with great frequency when the tubers are stored under damp conditions, and is very common in the stores constructed by the cultivators in the field especially when covered up to avoid moth. . . . In the commonest form in the Poona district the tuber becomes first covered with mycelium, and then gradually becomes soft and watery. In no case does the skin become loose and puffed up by gas, but the portions rotting show depressions.

It must not be supposed that potatoes which carry mycelia or sclerotia in the surface, however, will inevitably become rotten. By far the larger proportion of tubers we have examined show, on incubation, signs of rhizoctonia infection. But the rotting of the potatoes depends on storage conditions. If the potatoes stored had plenty of air, and the moisture surrounding the potatoes was not allowed to increase, the danger of *rhizoctonia* rot has always been very small. And, moreover, potatoes actually produced by wilted plants did not rot on storage, provided the

* Shaw and Ajrekar :—The Genus *Rhizoctonia* in India. Mem. Depart. of Agriculture, India (Bot. Series), Vol. VII, No. 4 (1915).



Rhizoctonia Destruens on a Potato Tuber.



Powdery Potato Scab, from Mahableshwar.

necessary conditions of aeration were supplied. It has been often recommended that in order to protect seed potatoes from *rhizoctonia* rot, they should be dipped before keeping in a solution of mercuric chloride (1 in 1000) or in formalin (1 per cent.). If the skin of the potatoes is unbroken and if proper aeration in the store is obtained our experiments lead us to suppose that even this is not necessary. If the necessary conditions of aeration are not obtainable, no doubt the proposed method will be of advantage.

With regard to the wilt in the field, one result is clear from all our observations. The *rhizoctonia* wilt occurs at certain seasons and in certain fields. These seasons are generally those when the soil is liable to contain excess of water. Thus the disease is essentially one of the *kharif* season so far as good land is concerned, when the rains may cause almost any field to be at times waterlogged, at any rate in the various Deccan tracts. Again, in the *rabi* season the disease is practically confined to ill-drained fields. We venture to connect, in fact, the *rhizoctonia* wilt in our areas very largely with badly drained land. The soil always contains the fungus. The half rotten manure used contains it in abundance. The potato tubers themselves also generally carry some infection with them. But all these are not sufficient to produce wilt if the field conditions are satisfactory, in point of drainage. It is in fact, in the study of the improvement of the cultural conditions, that the best hope of dealing with *rhizoctonia* wilt lies.

C.—Potato Powdery Scab.

This disease of potatoes, which has not hitherto been noticed in India as far as we can tell, and which is apparently only important in the hill districts, need not detain us long. We found it, under the name *khuzali*, as a serious blight at Mahableshwar where it occurred almost everywhere. Again in examination of potatoes from the Nilgiris we found it

frequently, and in considering the question of seed for and from these centres it must be continually kept in view as a disease of importance, and one which may, under suitable conditions, lead to a reduction in crop, and in the value of the crop reaped.

The disease is caused by a fungus, *Spongospora subterranea*,* which produces scabby spots on the potato-tuber. These scabby spots "are at first raised above the general surface of the tuber, and form patches one eighth to one quarter of an inch in diameter. . . . The parasitic fungus literally gnaws away the surface of the tuber which in some cases resists the parasite by forming a protective layer of cork, but usually the powdery snuff-coloured spore balls are the most prominent feature. Hence the name of 'powdery potato scab' sometimes given to the disease."†

The disease seems to be almost peculiar to cooler regions, but where the climate is suitable, it is produced where affected potatoes are planted, or where healthy potatoes are planted in infected soil. When infected tubers from Mahableshwar were planted in the Poona-Khed area, no infection resulted, as the climate of the latter region was probably too warm. This is in accordance with experience elsewhere, and particularly in America. Infection, in our experiments, does not occur when the affected potatoes are stored with sound tubers.

The matter is important, however, so far as Mahableshwar and the Nilgiris are concerned. And this being so, we may say that no method of eradication has yet been found. No soil treatment will clear out the disease, though sulphur at the rate of nine hundred pounds per acre, applied broadcast, reduces the amount of infection.‡ Seed treatment

* The best account of this fungus is by Melhus, Rosenbaum, and Schultz in the *Journal of Agricultural Research*, Vol. VII (1916), page 213. The disease is mentioned by Butler—*Fungi and Disease in Plants* (Calcutta 1918)—but he does not say definitely whether he has noticed it in India.

† McAlpine—*Potato Diseases in Australia* (1911), page 78.

‡ Melhus, Rosenbaum, and Schultz (*loc. cit.*),



PLATE V.

Eelworm Disease of Potato.

with certain chemicals notably mercuric chloride or formaldehyde will reduce the disease. No resistant variety is at present known, and though early harvesting may sometimes prevent infection it cannot be relied upon. The matter obviously needs very careful further investigation in the districts (above noted) which are already affected, in order that the extension, in hill districts, of this very serious potato rot may be prevented, and it may be eradicated where it already occurs.

D.—Eelworm Disease of Potato (Devi).

During the course of our field investigations of potatoes in the Khed area we found in 1917, first at Peth, a large number of plants affected by a peculiar form of scab, which was termed '*devi*' by the cultivators, and which particularly affected the *kharif* or rains crop. This has now proved to be a widespread disease of potatoes in India, both in the field and in storage, and has been found, on careful examination, to be produced by a species of nematode or eelworm, probably identical with that which has been found to cause a similar disease in America and elsewhere.

"This disease is caused by a minute nematode worm . . . which is so small as to be almost invisible to the naked eye. The mature female is nearly pearshaped . . . being less than a millimeter in length. . . The male is a slender thread like worm from 1 to 1.5 millimeter in length. The development of the female takes place within the underground tissues of the host plant, and its presence in these tissues is indicated by enlargements or malformation . . . The skin is roughened and broken in patches."* The roughened part shows small shining spots, which are very characteristic of this disease, and distinguish it from others with which

* C. S. Scofield—Nematode Eelworm on potatoes and other crop plants in Nevada, United States of America, Department of Agriculture, Bureau of Plant Indus, Circular No. 91 (1912).
N A 18—10

it might be confused. In the field, in an advanced stage of the disease, protuberances are formed on the surface in which eelworm are found. In storage these protuberances disappear and the worms apparently invade the deeper tissues.

The eelworm which causes the disease attacks many plants, and it has been recorded on no less than five hundred of them including most garden crops, lucerne, clover, grain crops, fruit trees and weeds. The young eelworms as a rule enter the plants from the soil by the tip of the rootlet, and they also pass into the young potato tubers through the lenticels, several entering frequently at the same part. Experiments elsewhere seem to prove that they are spread by seed potatoes, and that they may be carried in irrigation water. When soil is thoroughly dried, the eelworms are apparently killed, and when potatoes are eaten by an animal, the dung of the animal is said *not* to convey infection.*

Our own experiments indicate quite conclusively that seed potatoes attacked by eelworm cause the disease in the crop produced from them, and that infection is certain even in soil which has never borne the crop before. Infection through the soil was equally certain where river soil, which had never grown potatoes, was infected by means of scrapings from eelworm-infected potatoes; the crop grown was attacked in every case. Where a pot containing infected soil was kept for three months, the soil still remained infective, whether the pot had been watered in the meantime or not.

In storage we found that the affected potatoes rapidly become rotten, the type of rotting being a soft, but not wet, rot. The eyes were not affected, and the sprouts were actually forming after three months in storage. It is obvious that in attempting to deal with this disease, it is essential to get rid of as many of the eelworms as

* Monthly Bulletin, Comm. on Horticulture. California, Vol. V, page 60 (1916).

possible in the soil, and to use seed free from living worms. As regards the soil it has been suggested in America that anything that will lead to the drying of the ground and its exposure to the sun's rays will tend to reduce infection. Thus deeper ploughing of the land with consequent exposure of the soil to the sun's rays in hot dry weather has been recommended,—though our experiments in this direction were, we must confess ineffective. As regard the seed we have found that fumigation with petrol was quite ineffective in killing the parasite. Dipping of the potatoes in copper sulphate or formaldehyde solution have been found equally useless elsewhere. It has been suggested that slight heat will kill the eelworm, and that if seed potatoes as exposed for 24 hours to a temperature of 104°F. the parasites will die.* We have not however, tried this ourselves.

The extent of the disease in India is not known, but we have found it in all parts of Western India. As regards stored potatoes it was worst in those obtained from Karachi. The seriousness of the attack seems to vary much from year to year. Thus in 1918, it was particularly bad in the Khed tract, while there was very little in 1919. The cause of these variations is not known and demands careful further investigation.

VIII.—FIELD DISEASES OF POTATOES LEADING TO LOSS OF CROP.†

By H. H. MANN, D.Sc., S. D. NAGPURKAR, B.AG., AND
G. S. KULKARNI, L. AG.

A.—*The Tambera Disease of Potato.*

In the Poona district the plants grown during the rainy season (the *kharif* crop) are severely affected by a peculiar

* Frandsen—Monthly Bulletin, Comm. on Horticulture, California, Vol. V, page 60 (1916)

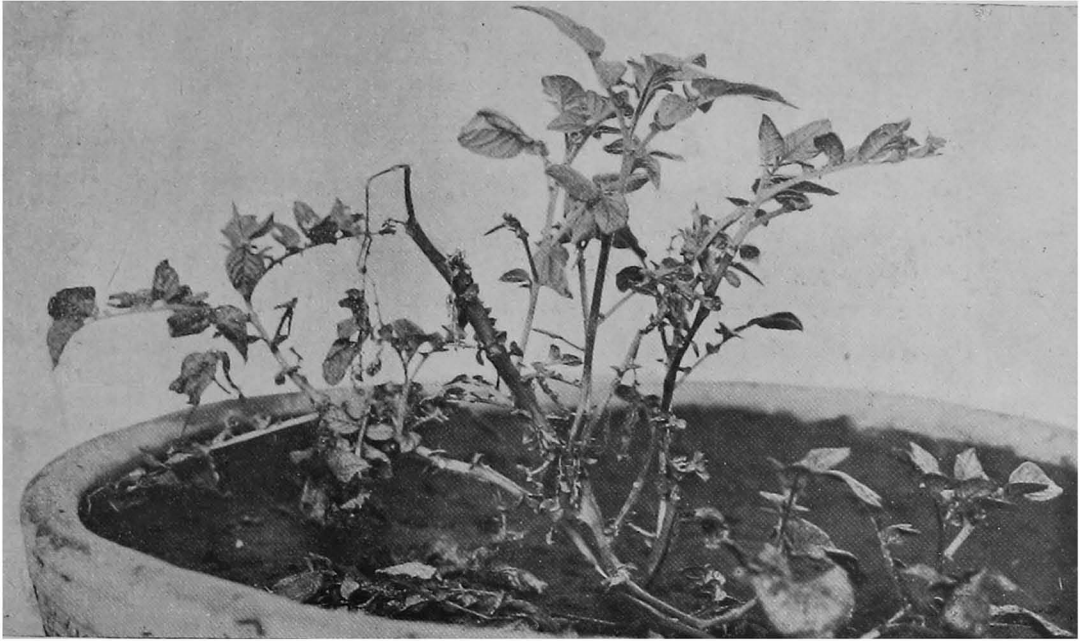
† We deal in this Chapter with the diseases we have studied. It is stated that potatoes at Gokak are always seriously affected with tip-burn, but we have never investigated it, and do not know what is the real cause of the affection.

disease, which, on account of the reddish colour which the affected fields acquire, has been termed *tambora* by the potato cultivators. The disease only attacks the *kharif* crop to any serious extent, but of this it is by far the most serious enemy, and, in a year where it is specially prevalent, it often means that the crop of potatoes is so small that the quantity of seed used is barely recovered. It prominently attracted our attention in 1917, and it has been under examination ever since.

The disease attacks the plants in the following manner. At any stage of the plant's growth, but generally after it is a month old, spots with a very slight, somewhat oily-looking, blackish colour begin to appear on the underside of the leaves, and especially on the younger foliage. These spots turn reddish, extend in area and in number very rapidly, and ultimately become a bronze colour, giving an almost uniformly reddish tinge to the leaves. The upper foliage of the plant acquires a bunched-up appearance, the edge of the leaves becomes wrinkled and the leaf hairs become very prominent. Gradually, commencing from the top, the whole of the foliage withers leaving however the main stalk still green and living, though it also ultimately becomes discoloured and withers (Plate VI, figures 1 and 2). The plant endeavours to recover, by giving out a series of auxiliary shoots, which are, however, rapidly attacked and wither accordingly. All these stages only require from thirteen to fifteen days from the beginning to the final ruin of the plants. The attack usually occurs after the tubers are formed and when they are about the size of a walnut. They cease, however, to develop further and hence the yield consists of a very small weight of very small potatoes.

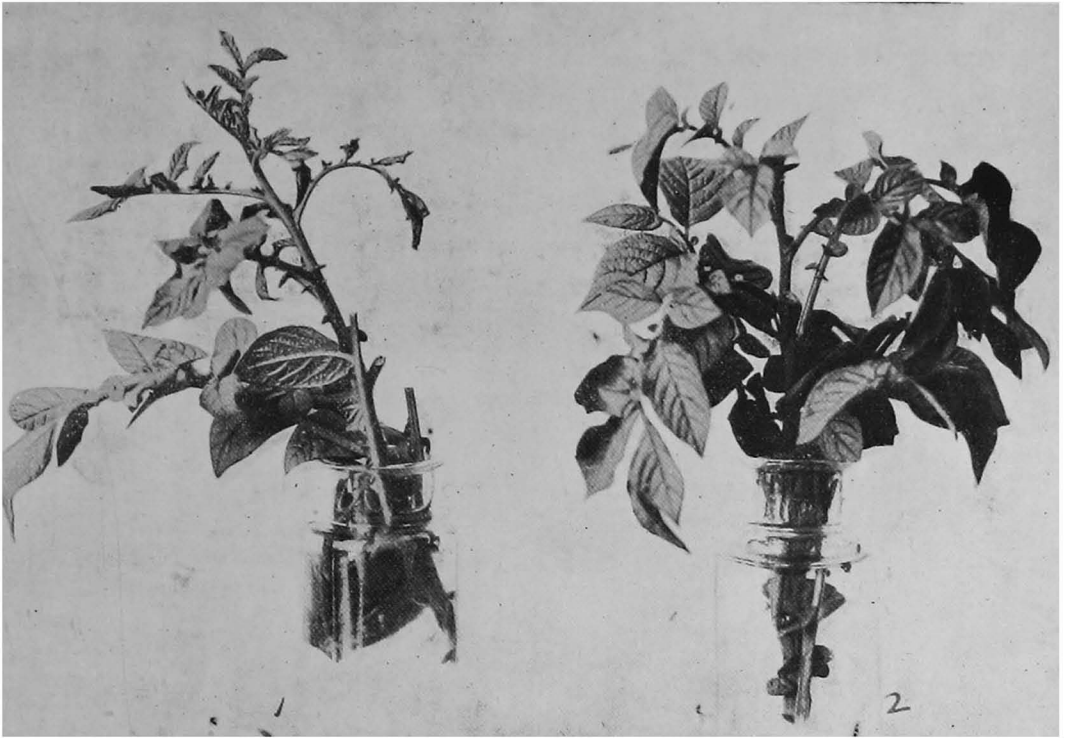
At first a few single plants are attacked, but from these the disease spreads in patches until the whole fields are affected. This spread is very rapid. As an example a

PLATE VI.
(To face page 78.)



2. Typical Attack of Tambera Disease.

PLATE VII.
(To face page 78.)



1. Plants inoculated with Tamera mite.

PLATE VII.



2. (1) Plant inoculated with Tamera.
(2) Control Plant without Inoculation.

patch of potatoes which was carefully watched in 1919 may be described. The whole patch of potatoes was thirty-three feet square. On the first day only four plants could be detected with the disease, three near one corner and another nearer the centre of the field. Five days later the whole of the corner of the field round the former plants and a large circular patch round the latter were obviously attacked. Three days after, the whole field was affected except a narrow strip down the middle, while on the thirteenth day from the commencement of the field was red and withering from end to end. The disease comes on almost as if a fire is passing through the fields and is universally attributed by the cultivators to the prevalence of light, misty rain which often occurs during the months of August and September.

It is obvious that a disease like this is of very great importance, and it indeed appears to be the factor which limits the spread of the cultivation of potatoes during the *kharif* season in Western India. It has now been found not to be limited to the Poona potato area, but also occurs in other districts and even in Sind. It has been noticed in the *rabi* (winter) crop also, but there it never does any serious harm and it may be almost ignored unless this crop is very late.

All attempts to trace the immediate cause of the disease for a long time proved futile. Fungus diseases were absent, and no trace of a bacterial affection could be found. Everything indicated that the attack was due to a parasitic attack of some sort, but it was not until 1919 that the nature of the parasite was discovered. At that time our attention was drawn to a disease which appeared to be of a very similar kind reported from Hawaii in 1917* and which was attributed to the work of a mite. The appearance shown in the illustrations of the disease seems to agree very closely with

* Carpenter, C. W.—"A new disease of the Irish Potato". *Phyto-Pathology*, Vol. VIII, page 286 (1918).

that shown in *tambera* and hence a careful search was at once made for the very minute mites described. We had already been able to produce the disease at will by growing the potato plants under conditions of high temperature, and on examination they were found to be swarming with mites exactly similar in character to those found in Hawaii.

These mites are found on all the affected parts, especially on the under-surface of the leaves of the plants. They are so small as to escape notice with the naked eye, until the eye is trained how to look for them, and even with a hand lens unless carefully looked into. They can, however, be easily seen in all stages under the microscope with a low power. The eggs are peculiar sculptured bodies rounded oval in shape, and firmly attached to the leaf. The egg cases, even after the emergence of the larvæ, persist for long time as colourless, transparent objects, still retaining the sculpturing in the form of rows of small opaque white globules. The young mites are hyaline, have three pairs of legs and are sluggish. They moult, and the skins thrown off by them are seen in great numbers as white specks. The adult female is a clear amber colour, with smooth glistening skin, and has a fourth pair of legs which are much thinner than the remaining ones. It is an oval active creature moving about on six legs while the other two are dragged behind, and measures one-fifth by one-tenth millimeter. The male is of the same colour with a brownish tinge but is quite different in size and shape. It is more orbicular and smaller, measuring one-tenth by one-eleventh millimeter, with a clouded dorsal spot, and it possesses strongly developed legs and is much more active than the female. The first pair of legs has two joints, the second and third pairs have five joints and the fourth pair has four joints and each joint bears a few hairs.

The mites apparently suck up the juice from the epidermal cells of the leaves with the result that the leaves

are unable to stand the heavy drain on them and wither prematurely. The mites then leave such leaves and go in search of fresh leaves which they easily reach by crawling over from plant to plant as the plants touch one another. Whether they are, like some other mites, carried by insects or other agencies is not known.

The naming of the mites is the work of a specialist. Carpenter does not attempt it. He makes a formal statement that they may belong to the same group as the so-called red-spider (*Tetranychidæ*).

The mere presence of the mite is not, of course, sufficient to enable us to attribute *tambora* disease to it unless the connection is proved by actual inoculation experiments. Carpenter in his paper does not record any experimental evidence, but bases his conclusions on the mere presence of the mites. He states as follows:—"That these minute organisms are responsible for the disease seems evident. They are present in sufficient numbers on the plants with the recognised symptoms to warrant this conclusion and the reaction of the plant is such as we have come to associate with mite injury. Furthermore, if the mites be kept off a portion of the plants by spraying or dusting with sulphur those so protected develop normally while adjacent unprotected plants are devastated."

The following inoculation experiments were, however, carried out. At first only two plants in pots were brought into the laboratory and on being convinced that they were quite free from the mite attack one was used for inoculation and the other as control. Inoculation was made by putting, on the plant to be inoculated, affected shoots from a diseased plant containing mites. The inoculated plant began to show the symptoms on the third day. On the fifth day these were quite clear and on the eighth day the withering of leaves commenced (Plate VII, figure 1). The control plant kept away from the inoculated one did not show

any of the symptoms and remained quite healthy (Plate VII, figure 2). Encouraged with this trial, experiments were made on a greater number of plants. Ten plants were raised in pots. Five were used for inoculation and five for control. Inoculation of the plant was done as before (on the 5th of August 1919) by placing on them the affected shoots containing mites. The plants began to show the disease on the next day, and on the fourth day the symptoms were quite evident, namely the bunching of shoots and the browning of the under-surface of tender leaves. At this stage the examination of a browned leaf under the microscope showed any number of moving mites with their eggs. On the eighth day the shoots were completely bunched up and were much darkened in colour. In one plant leaves were withering. Thirteen days later, most of the top leaves of all plants were quite reduced in size and dried up. The controls remained quite healthy during this period. The results of the experiments conducted, in the same way, in the fields, too, were quite conclusive. Leaves affected with mites were attached to a few plants in a corner of a plot where there was no disease and the plants were kept under observation. The inoculated plants alone took the disease and the attack started from the point of contact with the affected leaves. The mites were again found in intimate association with the disease on the new plants.

The causal connection of the mites with the disease at once suggested a method of control by spraying with a sulphur wash, or by dusting with sulphur, and preliminary trials were made in pots where the potatoes were seriously affected. Both methods proved effective, and it was found possible to revive plants which were in a very advanced stage of the disease. Experiments on small plots proved equally effective.

The potato crop is so valuable that the application of such a spraying method as a safeguard against the disease

would pay well, and hence a limited area in the fields of the cultivators has been sprayed with lime sulphur wash, or dusted with sulphur, during the season of 1919, three dressings being given commencing from the time when the plants were three weeks old. The results were excellent and a demand at once rose from the people to spray their whole area. The season and the disease had, however, by that time advanced so far that it was impossible to do anything in that year. Spraying with lime sulphur wash, however, was a little more effective than dusting with sulphur. Three treatments were given—the first when the plants were three weeks old, the second when about six weeks and the third when they were between two and three months from planting. The difference between the yield of the sprayed fields and those unsprayed in the immediate neighbourhood in 1919 was very great. The yield of the unsprayed plot was only 1,000 lbs. per acre, or practically the amount of seed used: that of a plot sprayed after the attack commenced was 5,000 lbs. per acre; that of a plot sprayed from the beginning was 8,720 lbs. per acre. The cost of the complete spraying treatment was Rs. 13 per acre, but this can be materially reduced. At present spraying, though more effective, is a new process to the cultivators and it is probable that dusting with sulphur from muslin bags will be more generally used.

An attempt has been made to see if any of the varieties available are immune to the disease. All those commonly cultivated are, however, rapidly attacked if conditions are favourable. An English variety "Epicure," in experimental trials seemed to possess some resisting power, but further experiments are necessary with it. The favourite variety in Poona, a round, white, Italian type, known in Western India as "Talegaon," was the first to be attacked, and the other local varieties soon followed.

It is difficult to say how the mites which cause the disease are carried over from year to year. Looking to the

field conditions of the tract where these observations have been made, it appears that the disease may possibly be carried over on the potato plant itself. Although there are two definite seasonal crops, the *kharif* and the *rabi* with regular intervals, the seasons are not sharply defined and potato cultivation goes on practically uninterruptedly between June and March. The *kharif* crop is sown in June and July and is harvested in September and October sometimes even in November. The sowing of the *rabi* crop begins in November and extends even up to the end of January, the harvesting of very late planted crops not being completed till the end of June. Stray plants arising from the remnant tubers of the previous crop are also found in the fields. It is thus seen that the potato plants are found throughout the year in the tract either as a regular crop or as stray plants, and the *rabi* crop though not seriously attacked is not by any means free from the mite. Owing to the cold weather the disease never does much damage and hence does not attract attention. The mite, however, comes into activity again as soon as the hot weather sets in in March and April. From the hot weather crop it is probably carried to the *kharif* season again.

Another possibility, of course, is that the mite may have other host plants. So far we have found what appears to be the same mite on *guvar* (*Cyamopsis psoralioides*) only. On this plant it has been recorded from Baroda, Padra, Surat and Poona. Cross-inoculations have proved that the *guvar* mite and the potato mite are one and the same. Potato plants when infected with the *guvar* mite easily took the disease. Chilli and tomato plants were also tried, but they remained free from the disease. More observations and experiments are required on this point.

B.—The Stem Borer of Potatoes.

There is a commonly occurring pest of potato in the whole of the Khed tract to which little attention has been

hitherto given, but which is well known to the people, as it occurs regularly and does damage, though not very serious damage, in both the *kharif* and *rabi* seasons.

The affection occurs in almost any stage of the plants' growth, when the top of the plant suddenly falls over and withers without affecting, however, the remainder. It never spreads lower in the plant. The people term this *mathe-maru* (that is to say 'the pest that kills the top') and on close examination a hole is found in the stem just at the bottom of the withered portion. The caterpillar, by which the damage is caused, pupates in the stem just below the hole to which we have just referred, and the pupating stage lasts from eight to ten days. In potatoes at Saugor (Central Provinces) a few pupae were found in the eye of the tuber, but this was no evidence of their doing damage to the potato.

The moth, which then emerges has been identified as *Leucinodes orbonalis*, a not unfrequent pest of brinjal (egg plant), but one which has only been recorded once or twice from potato. In this part of India, on the other hand, we have never seen it attacking brinjals, though on potato it is quite common. The eggs are usually laid on the underside of the midrib of the top leaves of the plant, generally one or two at one place and never in larger groups. Hatching of the eggs takes place after about nine days, but we have not been able to rear the caterpillar beyond this stage in confinement. On the plant in the field, however, we have been able to watch the life history and have found that the caterpillar requires fifteen to twenty days for its life, while the pupal stage lasts for six to eight days.

The caterpillar enters the stem at once, on hatching, and never does any damage to the leaves or to the outside of the shoot. The place of entering the stem is very small, and can only be seen with difficulty. The caterpillar is hairless and very sluggish (unlike that of the potato tuber moth which is active) and when mature is about one inch

in length. The moths are never observed flying and mating in the potato fields.

No experiments have been made to deal with this pest, but it often damages a very large number of plants as in 1917 and 1918. No evidence is in hand as to how far it affects the weight of the crop.

IX.—THE STORAGE OF POTATOES

BY H. H. MANN, D.Sc. AND S. D. NAGPURKAR, B.AG.

A.—*Black Heart or Heat Rot of Potatoes in Storage.*

In all work done on potatoes in India which involved storage there has been constant trouble because the potatoes when kept through the hot weather tended to show an enormous and unexpected amount of rotting. When such rotting potatoes were examined they showed in many cases a *fusarium* fungus, in many others a *rhizoctonia* fungus, and in others various kinds of what appeared to be forms of bacterial rot. And as a result it has been customary to attribute the hot weather rotting of potatoes in store to one or other of these causes. But the rotting often comes on so suddenly when the temperature rises and involves so completely almost the whole of a bag or a consignment of potatoes that it is difficult to believe that any or even all of the above causes were the main source of the rot which was liable to cause such tremendous destruction and loss.

It is extraordinary that attention has not been more closely directed to the subject until recently. Perhaps the real reason has been simply that potatoes are much more a temperate than a tropical crop, and the difficulties of storage have usually been rather those resulting from too low than from too high a temperature. All specifications as to the storage of potatoes* are so worded as to avoid the possibility of frost, and though the advisability

* See, for instance, Bulletin No. 724, United States, Department of Agriculture,

of preventing rise of temperature is insisted on, there is rarely if ever any indication that the temperature may be so high as to cause at least equal damage to that produced by freezing.

In India potatoes have, however, to be kept, at least for seed, over the hot weather, and the difficulties have been recognised by the people, and arrangements made to minimise the evil as far as possible. The description of the open air method of storage carried out by the cultivators in the Khed taluka will be found in Chapter V (page 33), but though the combination of shade, moisture, and aeration which their method secured gave them some security, yet every year when the temperature was high, the loss was enormous, and on opening the stores the potatoes were often covered with masses of fungus of various kinds and to these fungi the rotting has been usually attributed.

Attention was, however, called to the fact, by Bartholomew* in 1913, that a type of rotting, which he termed 'black heart' of potato is caused by rise of temperature alone especially if air is excluded and since that time the matter has been investigated by several people. The most recent account of it, with a very large number of experiments on the subject was published by Stewart and Mix in 1917.† The present knowledge of this rotting of the potato tubers due to heat together with lack of aeration is summarised by these last two workers as follows :—

“Present knowledge of black heart in potatoes rests upon investigations made by Bartholomew who proved that it may result from exposure of the tubers to a temperature of 38-45° C. for 14-48 hours and is due to changes in the tissues caused by a derangement of the process of respiration.

“The accidental discovery that by excluding the air from potatoes black heart may be produced at temperatures

* *Phytopathology* Vol. III, page 180 (1913).

† *New York Agricultural Experiment Station, Bulletin No. 436* (1917).

much lower than those employed by Bartholomew led the writers to make experiments with tubers in sealed jars.

“From such experiments it was learned that potatoes cannot long endure close confinement. Within a certain length of time, which varies with the temperature and quantity of air available, tubers confined in hermetically sealed jars become moist over a part or whole of their surface. If the tubers are then exposed to the air the moist surface areas turn brown and the colour of the flesh changes first from white to pink to black (black heart).

“With a volume of air equal to the volume of the tubers a confinement of ten or twelve days is sufficient to produce the symptoms described provided the temperature is around 70°F. At a temperature of 55-60°F. about twenty days are required; and at 40°F. a still longer time somewhere between twenty-three and forty days.

“Tubers in half-full and quarter-full jars behave similarly to those in full jars except that the symptoms are slower in making their appearance.

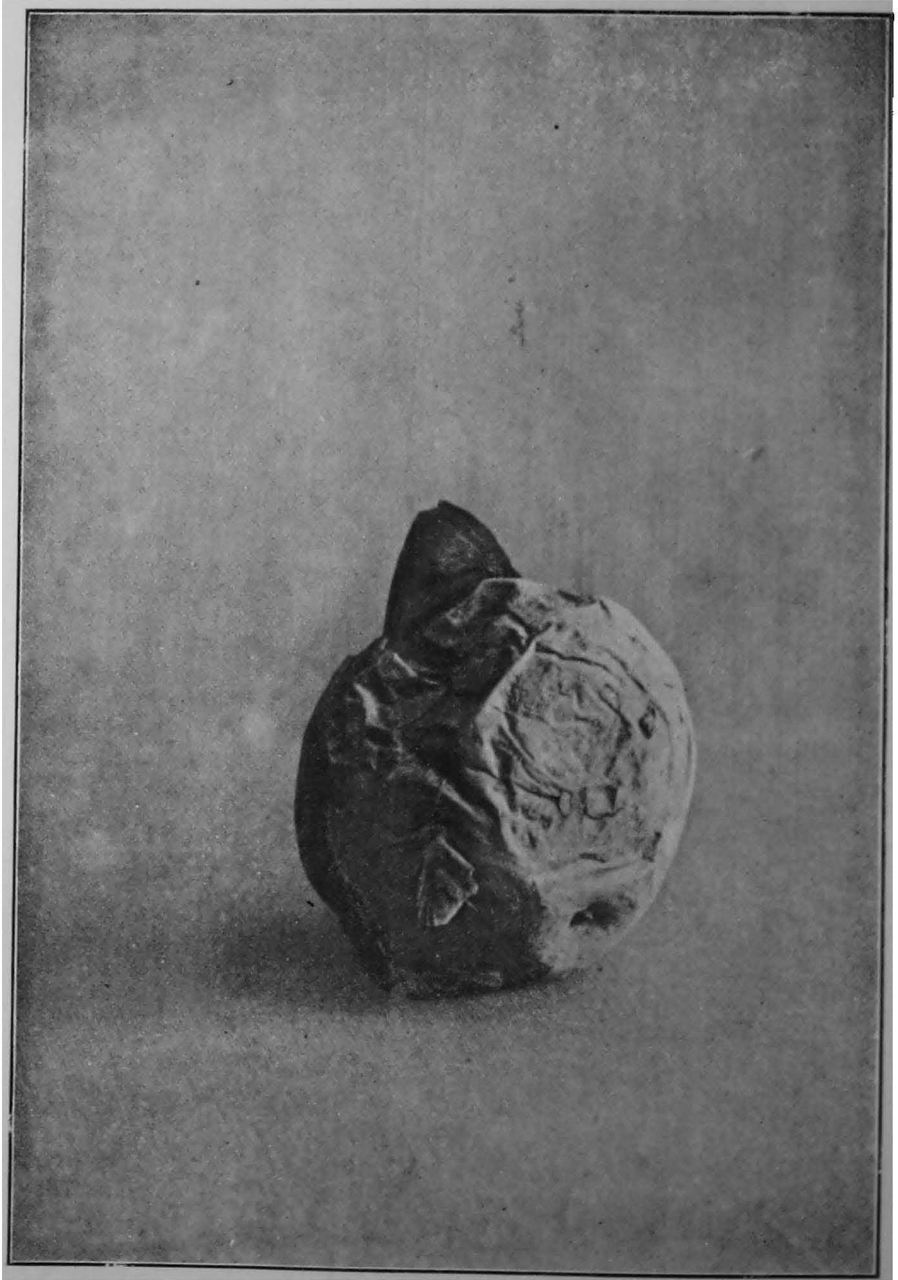
“Different tubers of the same lot exhibit marked differences in susceptibility, both to black heart and to surface discoloration. The cause of this has not been determined. It appears doubtful if the size of the tubers is an important factor.

“The injury resulting from insufficient aeration is due to the lack of oxygen rather than to the accumulation of carbon dioxide.

“Tubers affected with black heart produced by exposure to high temperature usually appear normal externally, while those affected with black heart produced by exclusion of the air usually show more or less surface discoloration.

“Tubers severely affected with black heart are unfit for seed purposes, but slightly affected tubers may be planted. If tubers are sound and normal in appearance it is unlikely

PLATE VIII.



Potato attacked with Heat-Rot.

that they have been injured for seed purposes by any storage conditions to which they may have been subjected."

Our attention was forcibly drawn to this type of rotting during the hot months of 1918, when we had a very valuable lot of pedigree potato seed which had to be carried through the hot weather. This was stored in bags in a well aerated and lofty room, facing north. The shade temperature outside, however went up over 100°F. and within a few days a large part of the stock became rotten and useless. This caused a much closer investigation into the subject, and the result has been to confirm in every particular the results just quoted, and to lead to methods which have enabled us to carry potatoes over the hot weather either in Poona or in the potato district itself. These methods will be described in the next section.

While we were doubtful as to the cause of the rotting which gave us so much trouble, we made experiments to see whether we had to deal with a parasite. As a matter of fact, *rhizoctonia* fungus (*rhizoctonia destruens* or *rhizoctonia solani*) is so universally prevalent among our potatoes that it is rarely that this fungus cannot be obtained by cultivation from them,* and it was at first thought that the rotting was due to this fungus. But the rotting produced by this fungus is essentially near the surface of the potato at any rate in the early stages, while the 'heat rot' is very deep-seated and in fact appears generally to start from the heart. The *rhizoctonia* rot is, moreover, very much blacker in colour, and on the whole, the two can be very easily distinguished.

No other parasite is usually present, and the 'black heart' is 'heat rot' is in no way infectious. Good potatoes can be treated with the rotting material in any way without any effect being produced. The tubers can be buried in soil mixed with the rotting potatoes, they can be cut

* The cultivations made from these potatoes were all very kindly carried out for us by Mr. G. S. Kulkarni, B.Ag.

with a knife just used to cut a rotting tuber, or they can be watered with the watery ooziings from an affected potato, without effect, provided the temperature be not allowed to rise or aeration to be restricted.

As already indicated by the above quoted authorities, the heat rot when highly developed causes loss of germinating power, and the potatoes cannot be used for seed. This has been found on a large scale in 1920 where the people of Khed and one or two other villages bought Italian seed with the object of planting it near the end of February. It was attacked with the rotting, and was then planted, almost entirely in vain, only a few plants growing out of the crop. But if the attack has only just started, and there is little or no sign on the outside of the tuber that the black heart is present in the tuber, the potatoes will grow healthily, and give good healthy plants. At present it is impossible to say exactly at what stage the tubers lose their power of germination.*

Enough has been said with regard to the 'heat rot' or 'black heart' of potato to show how vital a factor it is in the potato problem in Western India. If we can eliminate this kind of rotting, then the other fungus rots of storage (except perhaps *fusarium* rot) will not, we feel, be really serious obstacles to progress. But this heat rot makes the keeping of large quantities of seed a very difficult problem, and so far as potatoes for food are concerned makes a regular market a very difficult thing to maintain, fluctuations of price being extraordinarily great. What we have been able to find out and apply in actually storing potatoes will be discussed in the next section.

B.—Methods of Storage of Potatoes through the Hot Weather.

The shade temperature conditions^o in the Deccan, that is to say in the Poona and Khed area, during the time when

* The results of a chemical study of the effect of black heart on the potato is given in the Appendix.

potatoes have to remain in storage between February and June are shown in the following figures for Poona. Those from Khed will be very similar, while the higher plateau at Peth and surroundings village will be a little cooler :—

Temperature.	February.	March.	April.	May.	June.
Mean maximum ..	91·3°F.	99·1°F.	101·7°F.	100·1°F.	91·9°F.
Mean minimum ..	57·2°F.	63·1°F.	68·6°F.	71·6°F.	72·6°F.
Absolute maximum in 5 Years).	99·5°F.	105°F.	108·1°F.	107·6°F.	105°F.
Absolute minimum in 5 Years).	42°F.	48·5°F.	50·5°F.	65·6°F.	67·4°F.

Now our experiments have indicated that, apart from actual diseases present in the tubers, there is no danger in storing potatoes at any temperature below 86°F. and little danger below 90°F. provided that there is sufficient aeration among the stored tubers. The above table will show that the period of danger, therefore, when there will be some difficulty in keeping the temperature down to this point, will really start in March and continue until the latter part of May, and this is actually found to be the case in practice. It is during this period from early March to the end of May or later if the monsoon rains are delayed that the difficulty of storage occurs.

To get over this period without ruining their seed potatoes the cultivators use the method of field storage which has been already described (page 33) but which essentially consists in digging a shallow pit under the shade of a tree or under a roof, filling this with water and allowing the latter to soak away. The potatoes are then spread in it eighteen inches deep and covered with grass and broad leaves. The temperature is kept down by occasionally filling a ditch dug round the pit with water, and splashing the heap of potatoes with water. In such heaps we found the temperature rose to 92°F. to 93°F., but so far as our tests went, not higher than this. If the shade is considerable the temperature does not rise so high, and one store at Chakan

which only reached 86°F. was noticed. Thus in such heaps the temperature keeps fairly well within a safe limit, and if the potato moth was not a serious trouble, there would be little need of any better system.

Many other cultivators store in substantially built store houses in the village. Here the potatoes are usually kept in heaps from two to three feet thick, and in the case of seed potatoes, they are turned over and sorted frequently. The temperature in these heaps at the latter part of May was between 86°F. and 88°F. and occasionally it rose to 93°F. This was the highest temperature that we found. Again the method seems fairly satisfactory in the absence of potato moth, but with the latter in the houses (as is often the case) the system breaks down and there is a very large loss. In fact if potato moth cannot be eliminated there is no practicable method of storing except in bags. We would say, however, that when the process of fumigation of potatoes becomes general, it will probably be possible to revert to these two methods, as the amount of potato moth will be reduced within very small limits. At present this is not the case, and storage in bags is essential, in order to protect the fumigated seed from reinfection by moth.

Before going on to consider the methods which we have used to make storage in bags reasonably safe, let us consider some examples of the actual losses in storage which now occur by the ordinary cultivators' methods as described.

Field Storage.—

(1) *Village Khed.*—Stored from March 24th to June 6th. Quantity stored—20 tons.

	Per cent.
Loss due to moth attack ..	10
Loss due to dry rot ..	4
Loss due to miscellaneous wet rots	13
	<hr/>
Total loss ..	27

(2) *Village Peth.*—Stored from April 2nd to June 4th. Quantity stored—15 tons.

	Per cent.
Loss due to moth attack ..	30
Loss due to dry rot and miscellaneous wet rots ..	6
	<hr/>
Total loss ..	36

House Storage.—

(1) *Village Khed.*—Stored from March 24th to June 1st. Quantity stored—5 tons.

	Per cent.
Loss due to moth attack ..	12
Loss due to dry rot and miscellaneous wet rots ..	7
	<hr/>
Total loss ..	19

(2) *Village Chakan.*—Stored from April 13th to June 3rd. Quantity stored—6 tons.

	Per cent.
Loss due to moth attack ..	5
Loss due to dry rot and miscellaneous wet rots ..	3
	<hr/>
Total loss ..	8

(3) *Village Awasari.*—Stored from April 6th to June 5th. Quantity stored—40 tons. Temperature did not exceed 88°F.

	Per cent.
Loss due to moth attack ..	32
Loss due to dry rot ..	5
Loss due to miscellaneous wet rots ..	33
	<hr/>
Total loss ..	70

These cases are not typical, but represent the results obtained by careful men in the Khed potato area. The loss in the last quoted case is not unknown even among the best men if the seed used in the field for growing has been unsatisfactory.

Now from what has been indicated previously (page 37) the loss from moth attack can be eliminated, or practically so, by fumigation. This should be done a few days after the potatoes are lifted, as described previously. For the purpose of fumigation they are contained in bags, and after fumigation the next necessity is that before being put into storage in these bags the potatoes should be removed and carefully sorted. When this sorting is done they can be stored with safety in bags in the houses which the cultivators usually use for this purpose. Examples of such storage are as follows:—

A. Village Peth.—Stored from April 2nd to June 4th. Quantity stored—35 tons. Fumigated, sorted and bagged and stored in the usual house.

	Per cent.
Loss due to moth attack ..	<i>Nil</i>
Loss due to miscellaneous rots ..	9·4

B. Village Shirolī.—Stored from March 30th to June 6th. Quantity stored—6 tons. Fumigated, sorted and bagged and stored in house.

	Per cent.
Loss due to moth attack ..	<i>Nil</i>
Loss due to miscellaneous rots ..	2·3

C. Village Khed.—Stored from March 24th to June 6th. Quantity stored—1½ tons. Treated as in the last case.

	Per cent.
Loss due to moth attack ..	<i>Nil.</i>
Loss due to dry rot ..	1·7

The secret of success in the above cases was the sorting of the potatoes from every form of rot before final bagging after fumigation. Fumigation alone will not do; it gets rid of moth but other rots tend to increase rapidly in the stored potatoes. But if to fumigation is added careful sorting of the fumigated potatoes before storage and keeping of the potatoes below a temperature of 90°F. in a well-aerated house, there ought to be little further difficulty.

In order to get these results, however, the following precautions must be taken :—

- (1) Each bag must stand separate from all others, having free air all round it.
- (2) The bag must be completely filled tight, so that the folding of the bag will not prevent aeration.
- (3) The bags must not be piled upon one another.
- (4) The bags must be stood upright.

In our experience if any of these points are neglected there is a tendency for the temperature in the bag to rise, and cause loss through heat rot.

As an example of what can be done by these methods with a fair average lot of good seed, we will indicate the system adopted during the last famine in 1919 to preserve the local stock of seed potatoes which had almost disappeared on account of the drought conditions. Part of the stock, amounting to 70,800 pounds, were preserved at Peth without any special arrangements not obtainable in a village—while parts were preserved in Poona in a specially constructed storage house.

The stock at Peth was by no means a satisfactory one, as has already been stated. We purchased what was available from cultivators of good repute, after a preliminary sorting from obviously diseased or very inferior seed at the time of purchase. This eliminated 33 per cent. of the stock

offered to us for sale,* The remainder had to be stored from April to the latter end of June. During this time we lost potatoes as follows :—

(1) Lost owing to ring disease ..	407 lbs. or 0·57 per cent.
(2) Lost owing to dry rot ..	1,117 lbs. or 1·58 per cent.
(3) Lost owing to miscellaneous wet rots	1,683 lbs. or 2·37 per cent.
(4) Lost owing to heat rot ..	178 lbs. or 0·25 per cent.

The total loss was therefore 4·77 per cent. exclusive of drriage.

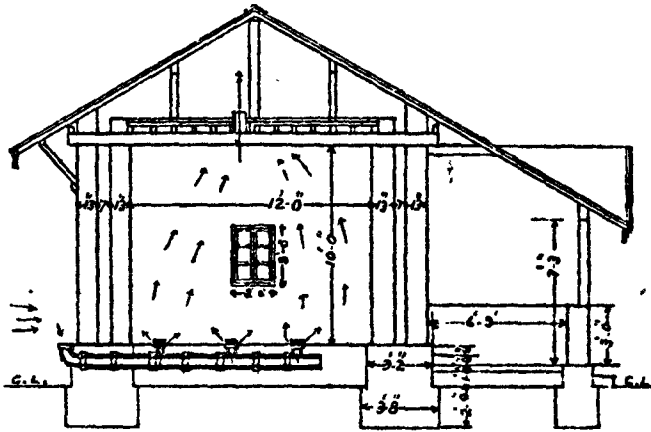
To obtain this result the bags of potatoes were fumigated with petrol vapour immediately on receipt in order to get rid of moth which was present though not a very serious extent. One fumigation was not found entirely sufficient, so after a sorting for ring disease, a second fumigation was undertaken. The actual storage was made in stone walled houses in Peth village. The temperature outside went above 101°F. and in an ordinary open shed with stone walls to 95°F. In our stores we were able to keep it down to 91°F. without special cooling arrangements,—but we finally adopted a system of hanging canvas sheets round the sides of the stores wherever air could enter, and keeping

* It is interesting to note the reasons for this elimination of potatoes offered for sale. They were as follows :—

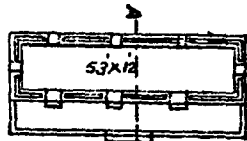
Total amount of potatoes offered	108,000 lbs.
Rejected—	
(1) On account of ring disease	6,300 lbs.
(2) On account of dry rot	14,100 lbs.
(3) On account of miscellaneous rots	2,700 lbs.
(4) On account of very small size of potatoes	12,900 lbs.
Total rejections	36,000 lbs. (33 per cent.)

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POTATO STORAGE HOUSE



SECTION ON A R.



PLAN



SECTION THROUGH WINDOW

these wet. After the adoption of this method, the temperature did not rise above 85°F. and heat rot, which was just starting, was checked. On the other hand, the attack of *fusarium* (dry rot) went on increasing, and we made the greater part of the loss on this account in the last three weeks of storage. All storage was in bags, with repeated sorting.

During this storage the following points were noticed :—

(1) Potatoes harvested a little before the plants became completely ripe and yellow, kept better than the others, especially so far as dry rot (*fusarium*) was concerned.

(2) Potatoes which had been treated carelessly by the cultivators in that they had been exposed to hot winds showed almost immediate signs of heat rot in the tubers. Once heat rot showed itself in a tuber nothing could save it from complete rotting.

(3) We formed the conclusion, which needs confirmation by further experiment, that the potato moth caterpillar is an important means of spreading various rots in the store, especially dry rot and some of the forms of wet rot.

(4) Potatoes affected with ring disease do not usually rot in storage, unless the attack is already in an advanced stage.

The conditions in Poona were more trying for here the temperature was higher, the maximum reaching 103°F. during the storage months. But here we had the advantage of a specially built storage house, placed at our disposal by Messrs. The Union Agency of Bombay, which is, we believe, the first of its kind in Western India. The place was designed to protect against moth infection from outside, and also against high temperature and the resulting heat rot.

The plan of the building is as follows :—As the essential point was to keep the building cool, well aerated and

inaccessible to potato moth, it was made on all sides with double walls with an air space between them, and on the south a verandah six feet wide. The store room itself was thirteen feet wide and the windows and doors could not only be closed during the hotter part of the day, but also, when open, were covered with wire gauze, permanent in the case of the windows, and forming an inner door in the case of the doors. The roof was of tiles, but underneath this was a ceiling covered with earth to a depth of four inches. The ceiling was open all round the edge and was pierced by several openings in the centre. There was a chimney in the roof through which, in the hot weather, there was a continual draught.

During the hotter part of the day both doors and windows were closed, and at this time aeration was obtained through holes in the floor, which were connected with the outside air by means of drain pipes partially filled with water. The whole arrangement is shown in the section of the building illustrated in the accompanying plan. Skeleton shelves can be built in the store room which will allow two layers of bags of potatoes to be stored without in any way interfering with the aeration of either layer.

The store room so built has been a distinct success in Poona, and though somewhat expensive in first cost, it prevents a great deal of rotting. The windows are kept open from 8 p.m. to 6 a.m. in the hot weather, and are then closed. The temperature has been kept as low as 82°F. when the outside shade temperature has been rising as high as 101°F.

We have, therefore, reached a system by which potatoes kept for seed can be maintained without anything like the serious losses which have often, if not usually, been incurred in the past. It is based on fumigation in the first instance, followed by rigid selection of diseased potatoes, and then storage in bags kept separate from one another in a godown so arranged that the temperature shall not rise above 90°F

Unless these conditions can be secured, potato storage in the hot weather in the Poona district seems impossible without very large loss.

In detail, the method is as follows :—

(1) Within a week or ten days of harvesting the stock of potatoes contained in bags should be fumigated with petrol vapour as described in the chapter on the potato moth. This can be now done easily as fumigation chambers are established in a number of the villages of the Khed potato tract, and fumigation carts can be taken to other centres.

(2) After fumigation the potatoes should undergo a rigid selection for ring disease, *fusarium* (dry rot), and any miscellaneous wet rots which are contained in the stock. Most of the rejected potatoes can be sold at once for food purposes.

(3) The potatoes should then be rebagged, and stored in a stone-walled godown or in one specially made (as described above). The bags must stand separately, must be full, and they must not be piled on top of one another. The godown must have a free through draught of air, and (in the absence of special arrangements to achieve the same object) the open doors should be hung with curtains of canvas kept wetted during the hotter parts of the day.

(4) After each month in store the bags should be opened and rotten potatoes should be removed.

X.—THE MANURING OF POTATOES IN WESTERN INDIA.*

By H. H. MANN, D.Sc., S. R. PARANJPYE, M.AG., AND
S. D. NAGPURKAR, B. AG.

Potatoes are recognised throughout the area now under consideration as an intense crop which will pay for a good

* Most of the information in this Chapter will be found in Bulletins Nos. 76 and 89 of the Bombay Department of Agriculture by H. H. Mann and S. R. Paranjpye.

deal of expenditure in the way of manure, and it is therefore usual for the people in almost every tract to utilise a considerable portion of the limited amount of manure available on the potato crop. Artificial manures have, except in experiments originated by ourselves, practically not been employed. In spite of the utilisation of whatever farmyard manure is available, the lack of sufficient of this to give all that the plant needs is one of the causes of the low yield obtained, and if the losses caused by the low quality of seed used, and the field diseases to which we have referred can be minimised, it will pay to manure much more heavily than at present and to use artificial manures.

The best cultivators in the Khed tract give up to about 12 cart-loads (10,000 lbs.) of farmyard manure to the acre, and in addition they often fold sheep on the land which it is intended to put under potato. The following are examples of the actual manuring given in certain cases by some of the best known cultivators in the tract.

A. One cultivator of Peth on the *kharif* crop of 1917, put on 12 cart-loads (10,000 lbs.) per acre of farmyard manure, mixed this thoroughly with the soil, and then folded 500 sheep per acre for four days on the land. From land so prepared he obtained a crop of 11,845 lbs. per acre, weighed eight days after harvest.

B. Another cultivator of Peth, on the *rabi* crop of 1917-18, put on 12 cart-loads (10,000 lbs.) per acre of farmyard manure only, and mixed this thoroughly in the soil. From this he obtained a crop of 6,460 lbs. per acre, weighed eight days after harvest.

C. A cultivator of Awasari, on the *rabi* crop of 1917-18, put on 16 cart-loads (13,000 lbs.) per acre of farmyard manure, and mixed this thoroughly with the soil in the usual manner. He obtained 10,080 lbs. per acre, weighed some days after lifting. This area is renowned for high yields.

D. At Manchar, on the *rabi* crop of 1917-18, 12 cart-loads (10,000 lbs.) of farmyard manure per acre were used. The crop was 9,642 lbs. weighed as in the previous cases.

These may be considered as the maximum yields obtained in ordinary cultivation. It is recognised that much higher crops can be obtained, particularly in the *rabi* season, and on the offer of a prize for the maximum crop obtainable, a cultivator at Manchar used 24 cart-loads (20,000 lbs.) of farmyard manure per acre and obtained 15,700 lbs. per acre of crop, weighed as before. This may represent the highest yield ever obtained in the district.

The average yields are far lower and the quantity obtained in the Khed tract does not certainly average more than 5,500 lbs. per acre in the *kharif* season, and 6,600 to 7,700 lbs. per acre in the *rabi* season. It is probably lower than this.

Our experiments have chiefly dealt with the employment of artificial manures, and have been carried on since 1913-14. The standard system of manuring adopted was to put on the usual dressing of farmyard manure (10,000 to 12,000 lbs. per acre) and *in addition* a mixture of sulphate of potash (180 lbs. per acre), sulphate of ammonia (120 lbs. per acre) and superphosphate (280 lbs. per acre). The average results of experiments made with this manure in the *rabi* season of 1913-14 were as follows, the artificial manures being applied just before planting:—

	Lbs. per acre.
Farmyard manure alone	9,146
Farmyard + complete manure as above	14,912
Farmyard + superphosphate and sulphate of ammonia only	12,627

With these results the use of the artificial manures in addition to the local manure could be fully justified.

Experiments in later years have amply confirmed these results and have in addition shown that the amount of sulphate of potash can be reduced without very great loss of yield. In a series of experiments on this point the following results were obtained in the *rabi* season :—

	Lbs. per acre.
Farmyard manure alone	8,425
Farmyard + complete manure with 150 lbs. sulphate of potash per acre ..	14,010
Farmyard + complete manure with 112 lbs. sulphate of potash per acre ..	13,450

The reduction of the potash manure has evidently, in the last case, gone too far, with a corresponding diminution in yield.

Our experiments, further, have shown that as a source of readily available nitrogen, sulphate of ammonia is superior to nitrate of soda if the quantities used contain the same quantity of nitrogen. The formula used was :—

	Lbs. per acre.
Sulphate of potash	150
Superphosphate	112
Sulphate of Ammonia	120
or	
Nitrate of soda	170

A series of experiments with these mixtures gave results as follows in the *rabi* season :—

	Lbs. per acre.
Farmyard manure alone	9,875
Farmyard + artificial manure with sulphate of ammonia	15,699
Farmyard + artificial manure with nitrate of soda	13,866

We can, therefore, state clearly that the following mixture of artificial manures represents the best and most

paying dressing for potatoes that we know as yet in the Khed area when used in addition to the usual dressing of farmyard manure under the conditions already indicated :—

	Lbs. per acre.	
Sulphate of potash	150
Superphosphate	112
Sulphate of ammonia	120

Of course, if a reduction in price of nitrate of soda occurred, it might become more profitable, but there is no doubt that the nitrogen in sulphate of ammonia is actually more efficient with this crop.

With the use of this mixture it has been possible to get high yields, at the same time reducing the quantity of farmyard manure. In a prize competition among the cultivators of the Khed area, the following results were obtained :—

Manure.	Lbs. per acre.	Yield of potatoes. Lbs. per acre.
1. Farmyard manure	.. 20,000	15,700
2. Farmyard manure	.. 13,000	..
and 200 lbs. of the above-mentioned mixture of artificial manures per acre	..	15,324

In this case the possibility of replacing farmyard manure in the *rabi* season is clearly shown.

We have not done any satisfactory experiments on manuring in the *kharij* season and such experiments are useless until *tambora* disease is brought under control.

XI.—THE VARIETIES OF POTATOES GROWN IN WESTERN INDIA.

BY HAROLD H. MANN, D.Sc. AND S. D. NAGPURKAR, B.A.G.

We do not know when potato cultivation was introduced into Western India, and where the seed used was obtained

from. Though there are earlier references to the matter, the earliest clear and definite record of the cultivation in the Khed area was near Junnar in 1841. Later on, when any attention was paid to the potato cultivation it was found that the whole district was growing a round, white, smooth-skinned potato whose eyes were of medium depth. This had a somewhat thin skin, and white eyes. The eyes averaged ten per tuber. The flesh was yellowish-white, not granular. The stem of the plant was purple at the base. This variety was found, in the year 1884 and following seasons, according to the account given by the people, to be very susceptible to the disease which we now know as *tambora*. Then the ring disease came in, from what source we do not know, and this variety proved very susceptible and potato cultivation in the early nineties was in very serious danger of extinction. Under these circumstances, Italian white round potatoes, imported here for food, were tried for seed and did very well. This variety gradually replaced the older one, and very nearly all of what is now grown is of this type, though a few of the older variety are often found mixed with it. The Italian variety is itself not pure and contains, even as imported, an admixture of long red and oval red types also. Up to 1900 the Italian variety was not really popular, as the 'older type of potato previously grown was reputed to keep better and' not to be so susceptible to rot. The famine of 1900, however, as far as we can tell, destroyed the stock (as has again happened in 1918-19). The Italian seed was the only suitable and available seed to replace it, and was found, moreover, to yield better. Hence it has now all but completely driven out the older type.

The Italian white round variety which is now almost exclusively cultivated in the Poona and Khed area has the following characteristics. It is round, rather flat at the ends and with somewhat of a bulge in the middle. The skin is rough and thick, and the colour whitish brown. The number

of eyes is from ten to fourteen. The eyes are deep and white in colour. The flesh is white gradually becoming yellowish on exposure and granular. The stem of the plant is pale-green throughout. When grown here the tubers are not large, though as imported they are of good size. Their principal advantage is that (1) they are capable of giving a good outturn on black soil in both the *kharif* and *rabi* seasons, (2) though susceptible to *tambera* disease, they are less so than nearly all other varieties tried, (3) they will grow under conditions of greater heat than most exotic varieties which have been tried here, (4) the amount of rot (largely dry rot) in storage is less than with other varieties grown in India, (5) the arrangement of the eyes on the tuber is such that many sets can be made from one tuber, (6) on cutting the flesh the tuber remains yellow, forms a corky layer and does not rot.

This same variety is the principal one in cultivation at Belgaum, and Dharwar, Satara, Bangalore, Karachi and the Central Provinces. In Karachi and Bangalore, however, and in Ahmedabad a kidney potato is also grown which is the principal variety in North India and the lower Himalayas. This latter is also grown under the name of '*malti*' at Mahableshwar, and its characteristics are as follows. It is a long flat potato reddish-white in colour, with a thin and smooth skin and scarlet eyes. The eyes are very shallow, and are clustered at the growing end of the potato. The flesh is yellowish and waxy. The stem of the plant is green. This variety grows well in the early *rabi* season at Karachi and Ahmedabad, but will not stand hot weather anywhere, and even in the above centres the Poona (Italian) variety is chosen for the hotter parts of the year.

A few further notes may be given with regard to the other varieties grown at Mahableshwar.

1. *Mumbasa kidney*.—This kidney potato tapers very markedly at both ends and is very flat. The colour of the

skin is yellowish-white, and it is thick and rough. The eyes are shallow and the flesh is milk-white and granular. The stem of the plant is pale-green.

2. *Gulabi*.—This is a long, flat, kidney potato, with brown skin having a red tinge. The skin is smooth and thin, and eyes are somewhat shallow. The eyes are red, and the flesh of the tuber is white with a reddish tinge. The stem of the plant is pale-yellowish.

3. *Tambada*.—This variety probably also originally comes from Italy and is a round oval potato of a red colour. The skin is thin and smooth. The eyes are shallow and deep red in colour. The flesh is whitish yellow and granular. The stem is pale-green.

We have no record of the behaviour of these last three under cultivation in the hotter conditions of the Deccan.

Many efforts have been made to introduce the best English and other varieties of temperate climates in our potato areas. These have invariably failed, as when any crop at all was obtained, the yield was always much less than that got from the varieties already under cultivation. The record of the latest attempts to utilise some of these varieties, under our own control, may be told.

Seed tubers of the following well known varieties were imported in 1918 from England :—“Epicure,” “Great Scot,” “Ever Good,” “Iron Duke,” “Irish Queen,” “Queen Mary,” “Arran Chief,” “British Queen.” The results obtained from each of these in the Khed and Poona area was as follows in two seasons :—

	<i>Planted in October.</i>		<i>Planted in January.</i>	
	Yield per acre.		Yield per acre.	
	..	lbs.	..	lbs.
Local white round seed	..	9,427	..	6,800
Epicure	..	1,920	..	1,600
Great Scot	..	680	..	280

		<i>Planted in October.</i>	<i>Planted in January.</i>
		Yield per acre.	Yield per acre.
		lbs.	lbs.
Ever Good	.. ..	520	80
Iron Duke	.. ..	1,600	360
Irish Queen	.. ..	480	880
Queen Mary	.. ..	920	440
Arran Chief	.. ..	70	<i>Nil.</i>
British Queen	.. ..	2,800	560

These were also grown at Peth in the *kharif* season, but no crop was obtained, chiefly as a result of a bad attack of *tambora* disease.

Altogether we may note that all the varieties named suffer badly as soon as the weather becomes even slightly hot. Then they are attacked seriously with *tambora* disease, and in a few days the plots are completely scorched and withered. It is, obvious, in fact, that any variety to be successful here must have characteristics which have been very little considered in working out the very choice varieties in Britain. These characteristics are (1) a capacity to stand high temperature both when growing and in the store, (2) a thick skin so that dry rot and other rots may not attack the tubers as a result of infection in store, (3) if possible, a capacity to resist *tambora* disease, at least to a limited extent, (4) a general distribution of the eyes so as to allow economy of seed, (5) a capacity to yield well even under conditions of fairly high temperature and irregularity of water supply, (6) a power to grow in both the *rabi* season under irrigation and in the *kharif* season with rain.

XII.—GENERAL CONCLUSIONS.

BY HAROLD H. MANN, D.Sc.

The survey which we have now made of the conditions of potato cultivation and its difficulties in some of the more important tracts in Western India will not be complete

unless we try to piece together the results, and give an idea of the needs of this industry and of its prospects for the future. As we write, in 1920, the potato-growing industry has almost disappeared for the time being in the Khed and several other areas, as a result of the demands of Mesopotamia in 1917-18 which denuded the country of any surplus stocks, of the famine of 1918-19 which very largely destroyed the crops in the *kharif* season of 1918 and prevented the planting of the *rabi* crop in 1918-19: and of the impossibility of importing fresh supplies of seed from Italy in 1919 until almost too late for *rabi* planting in most centres and absolutely too late in many.

The immediate effect of the famine in 1918 can be illustrated by one or two figures. In the Khed tract the potato crop was reduced in the *rabi* season of 1918-19 from a normal area of about four thousand acres to only about three hundred and thirty. On the Peth plateau, where there is a group of potato-growing villages, the area under this crop went down from a normal of 716 acres to only 25 acres in the *rabi* season of 1918-19, and to 20 acres in January 1919-20 (*rabi*). At present the revival of the industry depends, as it has done after every famine since that of 1900, on the import of Italian seed. Neither the seed of north or of south India is suited for the black soil areas, and it is very difficult to get Italian seed at any rate when it is wanted, and it can only be stored with very great difficulty. The times when seed is particularly wanted are June when it is in demand for the *kharif* crop, and in October to December for the *rabi* crop. In 1919-20, to relieve the famine for potato seed, permission was obtained for the import of a certain amount of potato seed from Italy too late for the regular *rabi* season. It arrived at the beginning of January. Some parts of the Khed tract refused to have anything to do with it knowing that the planting was too late and it would be a failure. Others planted the seed.

In suitable villages those who planted by the third week in January got an excellent crop, but the character of the return from seed planted after that date rapidly got poorer and poorer as the date of planting got later, and seed planted on February 10th, even under the best conditions, returned only twice the amount of seed tubers used. We would definitely say now that for the Deccan tract any attempt to plant later than February 1st is most risky and foolish. Hence the result of the lateness of the arrival of this seed this year has been that much of it has never been planted, and as it was *rutu* and hence useless for food, and would not keep till the *kharif* season it has been lost. As a result it will be rather difficult to restock the district, by private enterprise, and in the near future.

But it is only a matter of time before the areas will be restocked with seed, and as the crop is one which yields a very large profit, it is important that its future history should not be so dominated by troubles and difficulties, as has been the case in the past. It was a recognition of the existence of the numerous difficulties that led to the investigations whose results up to date have been recorded in these pages. The report of Mr. Keatinge in 1909, quoted on page 33, gave some idea of the parlous condition of the industry, and close touch with the Khed district in connection with manurial experiments from 1913 onwards led to the taking up of the present study. As a result the chief obstacles in the way of development have become fairly clear, and we have, we think, been able to show how to meet them in part, while much more investigation will be required to enable the others to be conquered.

In the first place, we may say that it has become clear that the maintenance and keeping of good seed is the primary matter to which attention must be directed. The destruction of seed in store by the potato moth is the primary

difficulty. To this the cultivators have always asked us to devote the first attention, and they are right. The very simple method of fumigating the reaped potatoes in bags with petrol vapour and subsequent storage also in bags under specified conditions enables this difficulty to be met. We have established permanent fumigating chambers in five of the principal villages of the Khed potato tract (under the control of village potato associations, of which more later) and have also provided, under the control of the agricultural department, two travelling fumigators which can be taken from village to village. The extension of this system of fumigation of potatoes, at any rate if to be used for seed, is only a matter of time, provided we can get rid of the very large loss which has been usually incurred by storage in bags. It is obvious that this method of storage is necessary, if reinfection with potato moth is to be avoided.

We have succeeded in determining the conditions of such storage without large loss from rotting, and it only remains to bring the methods which have been worked out in general use. They are simple and can be applied in every village in the Khed tract. Essentially these conditions are three, as follows :—

(1) The rigorous sorting of the potatoes after fumigation, and the removal for immediate sale, of every potato which can be detected as suffering from ring disease, from dry rot however small the patch may be, or from any form of soft or wet rots. This sorting is troublesome, but there will be a market for most of the removed potatoes, if sold immediately; while they will be worthless, beside infecting others, if kept with the remainder of the lot.

(2) The careful storage of the good potatoes in bags which are stored in a well aerated godown with the bags (a) full up to the top, (b) standing singly, (c) standing upright, and (d) not piled one upon another. Aeration is necessary or rotting will be very great.

(3) The keeping of the temperature in the godown and among the stored potatoes below 90°F. so as to avoid heat rot. To achieve this, the store must be substantially built and roofed. This is not usually a difficulty in the Deccan, and in case the temperature tends to rise above the figure quoted it is necessary to hang canvas screens on the doors on the windward side of the godowns, and keep these wet during the hotter parts of the day. We had no difficulty in keeping the temperature to 85° to 86°F. in Peth by this method.

If these methods are adopted we think there will be little further difficulty in preventing the stored potatoes from rotting, and the seed will improve by the gradual elimination of the *fusarium*-attacked potatoes. It may be necessary to resort to the potatoes every month during the storage.

But all this will only provide good seed if ring disease be absent or almost absent in the tubers. We have shown that the seed is the sole important source of the perpetuation of ring disease, and it cannot be eliminated anything like completely by sorting. Its presence, however, in seed means the inevitable death of plants, and before the famine it prevailed to the extent of forty to fifty per cent. in much of the seed in use. To get rid of it, however, means continual renewal of seed from Italy or the establishment of pedigree seed, selected and grown here from generation to generation until free from the disease. The former is the simplest if the price of the seed is of no importance and if there is security that we shall always be able to get the seed that we want when we need it. If these conditions are not fulfilled it is necessary to adopt the second alternative and establish pedigree seed here practically free from ring disease. A step has been taken in this direction, and it would appear to be a legitimate sphere of operation of the agricultural department to maintain this seed in limited quantity, transferring

it for further multiplication to a commercial agency or to a quasi-commercial agency such as a co-operative society formed for the purpose.

The next necessity is the development and application of the methods for dealing with *tambora* disease. The recognition of this as the principal cause of small yields in the *kharif* season, and the most serious field enemy of the crop is quite recent. Nobody fancied two years ago that it did the damage it is now proved to produce. But the use of dusting or spraying methods, with sulphur or sulphur preparations, would seem to remove it from the category of real dangers, and so far as appears at present it would henceforth be a conquered foe, if only the necessary amount of trouble is taken.

If the programme so far outlined is carried out the principal difficulties in the way of the industry will be removed. There is much still to do. The study of the fusarium rot of stored potatoes has been hardly begun. The methods of dealing with the very destructive *rhizoctonia* wilt disease—which we believe will be chiefly by improvements in cultural methods—have hardly been investigated at all. The necessity of continual testing and even breeding of varieties in order to get a type which suits the conditions here better than anything we have at present is obvious. And the increase in the normal yield from the present very low standard by means of manuring is another method whose development is essential. These are the immediately necessary lines of progress, both in investigation and propaganda.

For propaganda work and the helping of the cultivators we have developed an organisation in five of the chief villages of the Khed tract which has worked well until the recent collapse of the industry and is still there. In each of these villages there has been established a 'potato association' composed of twenty of the leading potato cultivators. This

association is in charge of the fumigating chamber in the village and arranges how it shall be used by its members and by others. So far a fee has not been charged for this use, but that will be the next development. Then a young intelligent local cultivator's son has been selected and trained by us in each case to fumigate, to select seed potatoes, to store by the best methods, to detect the various kinds of diseases in the field, and as far as possible to deal with them. This man is placed under the charge of the potato association and is at the service of the members and of others with the members' consent.

The whole organisation has been supervised by one of those responsible for the work, who frequently toured in the district and kept closely in touch with the potato associations and their members, their men, and their difficulties. Such is the way in which the work has been carried on and its development is only a matter of time.

In conclusion we may say that the investigations and work which have formed the subject of the present bulletin have been rendered possible by special financial assistance from two or three sources. Messrs. The Union Agency of Bombay have assisted perhaps most largely in placing at our disposal one, and at times two graduate assistants, paying their salaries and all their expenses from the early part of 1917 to 1920. In addition to this, a special grant of Rs. 10,000 from the profits of the wheat operations in 1917, was made towards the cost of the work by the Government of India in 1918, and its continuation is now assured from a grant recently made by the trustees of the Sir Sassoon David trust for agricultural inquiries. We can only hope that the further progress achieved will lead to the solution of the remaining problems of potato culture, at least on the Deccan.

APPENDIX.

A CHEMICAL STUDY OF "HEAT ROT" OR "BLACK HEART" OF POTATO.

BY H. H. MANN, D.Sc. AND B. M. JOSHI, B.Sc.

I.—Introduction.

One of the difficulties constantly met with in tropical countries in connection with the cultivation and the keeping of potatoes is the fact that when the tubers are stored, at any rate in the hot weather, there is a very large amount of rotting among them. In the past this has been usually attributed to the presence of fungi and bacteria, and to a very large extent they are the cause of the loss incurred on this account. We have found fungi present on the surface of the potato always, and often beneath the skin (having entered probably through the lenticels) so that even after careful disinfection of the surface, fungal growth is still obtained. And, moreover, the conditions of storage at high temperatures are very favourable to the growth of such fungi and bacteria as may be present. But the wholesale rotting of whole consignments of carefully sorted potatoes, when the temperature rises, has often led to the suspicion that the fungi and bacteria usually found were not the primary cause of the decay.

Two special instances caused us to give close attention to the matter. In the first place, we had produced, prior to 1918, a somewhat valuable lot of pedigree seed potatoes, free from ring disease of the Italian variety usually grown in the Deccan, and during the war it was impossible to replace this supply from Italy or any other source. They were, however, stored during the hot weather of 1918, in bags, in a lofty and well-aerated room, facing north, in Poona. The temperature outside however rose to over 100°F., and within a few days a large part of the stock became

rotten and useless. When the potatoes which were still good were sorted out, and kept under very carefully cooled conditions at not over 85°F. no further rotting occurred. In the second place one of us organised the despatch of large quantities of seed potatoes to Mesopotamia in 1917 and 1918, and whatever care was taken in selection and packing, the report was always made during a large part of the year that before use a large quantity had decayed with a soft wet rot.

It was obvious, therefore, that we had to deal not with an ordinary parasitic attack, whether by fungi or bacteria but with some thing which was intimately connected with rise of temperature. And at this stage our attention was called to work done and observations made by Bartholomew * in 1913 and by Stewart and Mix † in 1917 in which descriptions are given of very similar rot produced, generally during shipment, in America. This rot was attributed by both the authorities quoted to rise of temperature, especially when the rise of temperature was accompanied by lack of aeration.

The general character of the change now under consideration is very obvious to the naked eye. While, in the presence of adequate aeration, healthy potatoes at a temperature of 27° to 30°C. do not appear to undergo any microscopic changes except a slow driage, when that temperature is exceeded, there occurs a darkening of the tissues, starting from the centre of the tuber with certain varieties but by no means with all. The original description given by Bartholomew in 1913 is absolutely accurate so far as some of our potatoes are concerned, but we would specially draw attention to the great differences that exist between the reaction of different varieties to the temperature factor

* E. T. Bartholomew—Black Heart of Potatoes—Phytopathology, Vol. III, page 180.

† F. C. Stewart and A. J. Mix—Black Heart and the Aeration of Potatoes in Storage, New York Agriculture, Expt. Sta. Bulletin, No. 436 (1917).

and hence to the production of heat rot. As found in the Italian white round potatoes with which we have worked, the course of the attack is usually as follows :—

The flesh of the potato, generally on one side, but sometimes in the centre takes in a pinkish tinge. This spreads over nearly all the tuber before any further appearance is noted. Then at any part of the tuber, but often near the centre, a small patch of dull dark colour appears, soft to the touch and in which, obviously, degeneration of the contents of the cells is taking place. At a temperature of 36°C. the changes to this part usually take about six days. Most of the potatoes at this stage have become soft, but one or two in every set of twelve remained hard, or rather increased in hardness. After this stage is reached further degeneration is rapid, and by the twelfth day the whole potato is greyish black in colour, very soft and pulpy often with watery matter oozing out, and it smells badly. No bacteria are present when precautions are taken, though it is often difficult if not impossible to eliminate *Rhizoctonia* fungus (*Rhizoctonia solani*) which often grows, in spite of all surface sterilisation in the tuber just under the skin.

The degeneration of the potato tuber which we have described is so marked, so rapid, and so complete that it was quickly felt to be interesting and possibly important to ascertain, if possible, the chemical changes which accompany it, particularly in the initial stages, in order that it might be detected and checked before it does any serious harm to a store of potatoes. We are not sure whether the results which we can now present will enable us to do what we hoped, but the experiments are sufficiently interesting to be worthy of record.

The design of our experiments was to compare the composition of similar potatoes which were kept, on the one hand under conditions of temperature and aeration where no obvious degeneration took place, and on the other,

where conditions of aeration being practically the same, the temperature was raised to a point where rapid rotting set in. The first experiments were undertaken to ascertain the temperatures which could be used for the purpose. The potatoes were enclosed in wire cages and placed in incubators at various temperatures. It was found that at 27° to 30°C. there was no danger of rotting under these conditions and that the potatoes remained good, without any signs of the darkening of the tissues which is characteristic of the degeneration for much more than the twelve days during which each experiment as a rule lasted. At 36°C. changes, however, took place under otherwise similar conditions and the potatoes became soft and the tissues darkened about six days after the potatoes were placed in the incubator. At this temperature the changes we were studying are slow and regular, and it was adopted as the standard for the study we were making. At 41° to 42°C. the degeneration was very rapid. Within two days the tissues were darkened, and in six days the tubers were completely soft and rotten.

In all these experiments small potatoes of even size were used and of course of the same variety,—the Italian white round potato grown in the Deccan. Each potato used weighed between 30 and 35 grammes. Tubers, kept as described, were taken for analysis at intervals of two or three days. Twelve potatoes formed each sample. Half of each of these were pounded to a pulp, and immediately examined. In most of the experiments, as already stated, the potatoes were in wire cages. In much of the later work, when we were testing the effect of various gases, the tubers had to be kept in sealed glass cylinders.

II.—Methods of Analysis Used.

The following determinations were made during the course of the work, and the methods used are indicated.

1. *Moisture*.—The moisture was determined by drying thin slices of the potatoes in the steam oven.

2. *Total Soluble Matter*.—The potatoes were pulped, a weighed portion of the pulp mixed with water, allowed to stand, filtered and the clear filtrate evaporated.

3. *Total Nitrogen* was determined by the ordinary Kjeldahl method, using potassium sulphate only (not mercury).

4. *Ammoniacal Nitrogen*.—This was obtained by distillation with magnesia, and titration of the distillate received in standard acid, with standard alkali.

5. *Insoluble Proteid Nitrogen* was obtained by washing the pulp first with cold and then with hot water, and then using the ordinary Kjeldahl method with the residue.

6. *Total Proteid Nitrogen*.—This was determined by mixing the pulp with water, and adding Stutzer's reagent (cupric hydroxide suspended in water). After standing in a steam bath for half an hour, the whole was filtered, the residue washed with hot water and then the nitrogen determined in it by the Kjeldahl method.

7. *Amido Nitrogen* was obtained as the difference between the total nitrogen and the other fractions determined. Thus Amido-nitrogen = Total nitrogen—(total proteid nitrogen + ammoniacal nitrogen).

8. *Soluble Proteid Nitrogen* was obtained by difference between the total proteid nitrogen and the insoluble proteid nitrogen.

9. *Reducing Sugar*.—The potatoes were pulped, 50 grammes were then taken and mixed with cold water, and allowed to stand for one hour. The whole was then filtered through linen cloth, and washed with warm and finally with cold water. The filtrate was treated with basic lead acetate and made up to 500 cc. After filtering, precipitating with sodium phosphate, filtering and concentrating, the reducing sugar was determined with Fehling solution in the usual fashion.

10. *Total Sugar*.—The original solution obtained in the last named determination, after filtering off the starch very carefully, was inverted with hydrochloric acid, and in the resulting liquid the total sugar determined with Fehling solution as usual.

11. *Gummy Matter and Dextrin*.—Twenty grammes of the pulp was extracted with 96 per cent. alcohol for three hours and filtered; 100 cc. cold water were added to the residue and the whole kept for 20 hours. Upon filtering a clear solution was obtained which gave no starch reaction with iodine. This solution was slowly concentrated to a small volume, avoiding a temperature higher than 80° to 90°C. and was then treated with several volumes of strong alcohol until no further precipitate was produced. The flocculent precipitate was filtered off and weighed giving the percentage of gummy matter and dextrin.

12. *Alkalinity and Acidity*.—Ten grammes of the pulp were taken mixed with cold water and kept for two hours. The liquid was then filtered, carefully washed, and titrated (1) with standard caustic potash using phenol phthalein as indicator to determine the acidity, (2) with standard sulphuric acid, using methyl orange as indicator, to determine the alkalinity.

13. *Catalase*.—Two grammes of the potato pulp was taken, and a large excess of neutral hydrogen peroxide solution was added. The flask was kept continually shaken for four hours, the temperature being maintained constant in a water bath. The gas evolved was collected and measured throughout the operation.

14. *Oxidases*.—The method devised by Bunzel* with minor modifications of technique was used. About 20 grammes of potato were taken, pulped and pressed through cloth. 2 cc. of the juice were used for the experiment and the actual tests were made at a temperature of 36°C. each being continued for four hours.

* United States, Department of Agriculture, Bureau of Plant Industry, Bulletin 238 (1913).

III.—Chemical Changes accompanying Heat-Rot in Air.

1. *Moisture.*—Potatoes kept in an incubator whether at 27°-30°C. or at 36°C. generally lost a little water, but as the atmosphere was always nearly saturated the drying did not usually go very far, and a loss of water or a change in water content did not seem to be in any way specially associated with the phenomena described. Two illustrations of this may be given—

A.—Potatoes exposed at 27°-30°C. and at 36°C. without any preparation or treatment :—

		Water determination in		
		(1) Fresh Potatoes.	(2) Potatoes at 27°-30°C.	(3) Potatoes at 36°C.
		Per cent.	Per cent.	Per cent.
Fresh Potatoes	.. ..	72·7	..	71·2
After 3 days exposure	.. ..	..	72·2	71·1
After 6 days exposure	.. ..	..	72·1	70·8
After 9 days exposure	.. ..	..	71·0	70·2
After 12 days exposure	.. ..	..	70·3	

B.—Potatoes exposed at 27°-30°C. and at 36°C. having been previously dipped in copper sulphate solution to check surface fungi :—

		Water determination in		
		(1) Fresh Potatoes.	(2) Potatoes at 27°-30°C.	(3) Potatoes at 36°C.
		Per cent.	Per cent.	Per cent.
Fresh Potatoes	.. ..	75·4	..	71·9
After 3 days exposure	.. ..	..	73·1	75·9
After 6 days exposure	.. ..	..	73·5	75·9
After 9 days exposure	.. ..	..	73·7	75·1
After 12 days exposure	.. ..	..	74·0	

In the first of these experiments the loss in the proportion of moisture in the tubers was practically the same in the two cases and amounted to 3·4 per cent. In the second case the loss was much smaller and was less at the higher temperature than at the lower.

The actual total loss in weight of the tubers is not very different from the loss in moisture recorded in the first case quoted above. The total loss in weight, in one case, was as follows :—

Loss of weight at 30°C.			Per cent.
(1) in 3 days	..	..	1·1
(2) in 6 days	..	..	2·0
(3) in 9 days	..	..	2·2
(4) in 12 days	..	..	2·7

Though respiration is taking place, as we shall see later, the greater part of the loss during the experiments is apparently due to diage.

2. *Total Soluble Matter**.—The following figures show the amount of total matter soluble in water at different stages. The present experiment was made with the potatoes in glass cylinders and was allowed to continue for twenty-two days, or long after the potatoes kept at the higher temperature were rotten, and when those at 27°-30°C. were also in a rotting condition :—

	<i>Total Soluble Matter.</i>	
	Potatoes kept at 27°-30°C.	Potatoes kept at 36°C.
	Per cent.	Per cent.
Fresh potatoes	16·4	16·4
After 2 days	16·4	16·8
After 4 days	16·4	17·2
After 6 days	16·8	17·6
After 8 days	17·6	17·2
After 10 days	17·2	16·8

* The results throughout have been calculated on the basis of the dry matter contained in the potatoes. Where this could not be determined it has been assumed as 75 per cent.

		<i>Total Soluble Matter.</i>	
		Potatoes kept at 27°-30°C.	Potatoes kept at 36°C.
		Per cent.	Per cent.
After 12 days	.. ..	17·2	17·6
After 14 days	.. ..	18·0	17·6
After 16 days	.. ..	17·6	20·0
After 18 days	.. ..	18·0	20·8
After 20 days	.. ..	17·6	20·4
After 22 days	.. ..	18·0	20·4

In both cases there is a small and very gradual increase in the amount of soluble matter in the potato. The rate of increase during the first twelve days does not, however differ in the potatoes kept at the different temperatures. The sudden rise after 14 days at 36°C. is obviously due to other causes and probably to the presence bacterial rots when the degeneration of the tuber has gone so far.

3. *Acidity and Alkalinity.*—The tubers used in the last determination were employed for the estimation of the acidity, and alkalinity. It might have been expected that the rotting described would be characterised by a substantial change in these characters. If the rotting were essentially a fermentation of the carbohydrates, then the acidity would be expected to increase. If on the other hand, it was a decomposition of proteids, the alkalinity might have been expected to become greater. Neither of these changes takes place. There appears to be an immediate rise in the acidity of the potato at the higher temperature, but thereafter it remains constant until the rotting is fully established (12 days) and only rises after that time when bacterial rots supervene. Likewise the alkalinity, though slightly higher at the higher temperature, remains constant until the rotting is fully established. All figures are calculated on dry matter and the figures represent

the equivalent of H_2SO_4 or sulphuric acid or potassium hydroxide respectively in one hundred grammes of dry matter.

	Acidity.		Alkalinity.	
	Potatoes at 27°-30°C.	Potatoes at 36°C.	Potatoes at 27°-30°C.	Potatoes at 36°C.
	Per cent.	Per cent.	Per cent.	Per cent.
Fresh Potatoes ..	0·96	0·96	1·92	1·92
After 2 days ..	0·96	1·32	1·92	2·32
After 4 days ..	0·96	1·16	2·20	2·20
After 6 days ..	0·96	1·16	1·92	2·20
After 8 days ..	1·16	1·16	2·20	2·20
After 10 days ..	0·96	1·16	1·92	2·32
After 12 days ..	0·96	1·16	1·92	2·20
After 14 days ..	0·96	1·16	1·92	2·32
After 16 days ..	0·96	1·36	1·92	2·48
After 18 days ..	0·96	1·56	1·92	2·48
After 20 days ..	0·96	1·44	1·92	2·40
After 22 days ..	1·16	1·48	2·20	2·40

4. *Forms of Nitrogen.*—As we had no wish to follow the changes subsequent to the complete establishment of the heat-rot, the investigation of the alterations in the various forms of nitrogen present in the tubers was not continued beyond the twelfth day, the tuber being kept

in open wire cages. The results were however as follows, all figures being based on the dry matter present in the tubers :—

	Total Nitrogen.		Ammoniacal Nitrogen.		Amido Nitrogen.		Total Proteid Nitrogen.		Insoluble Proteid Nitrogen.		Soluble Proteid Nitrogen.	
	27°30' C.	36° C.	27°30' C.	36° C.	27°30' C.	36° C.	27°30' C.	36° C.	27°30' C.	36° C.	27°30' C.	36° C.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Fresh Potatoes .	1·47	1·47	0·016	0·016	0·55	0·55	0·88	0·88	0·44	0·44	0·44	0·44
After 3 days ..	1·4	1·4	0·014	0·014	0·68	0·66	0·72	0·71	0·47	0·44	0·25	0·27
After 6 days ..	1·4	1·4	0·030	0·049	0·64	0·70	0·78	0·77	0·49	0·49	0·29	0·28
After 9 days ..	1·4	1·4	0·035	0·051	0·65	0·67	0·71	0·74	0·48	0·48	0·23	0·26
After 12 days..	1·4	1·3	0·048	0·088	0·68	0·66	0·71	0·75	0·46	0·47	0·25	0·28

The total nitrogen, therefore, obviously does not alter and the insoluble proteids are not dissolved during the process under discussion. There is furthermore no marked change either in the amido nitrogen or in the soluble proteids. On the other hand the ammoniacal nitrogen has increased very largely and while the increase is present even in the absence of the rotting, it is much more rapid at the higher temperature. The rapid increase coincides with the beginning of the degenerative changes between the third and the sixth day, and at the twelfth day the quantity of ammoniacal nitrogen is nearly double what it is at the lower temperature.

5. *Forms of Sugar.*—No investigation of the individual sugars was made, and we simply determined the total sugar and the portion of this which was capable of reducing

Fehling solution. The results were as follows, the tubers being kept in open wire cages :—

	Total Sugar calculated (as glucose).		Reducing Sugar (as glucose).	
	Potatoes at 27°-30°C.	Potatoes at 36°C.	Potatoes at 27°-30°C	Potatoes at 36°C.
	Per cent.	Per cent.	Per cent.	Per cent.
Fresh Potatoes	3·0	3·0	0·3	0·3
After 3 days	3·1	4·1	0·30	0·33
After 6 days	3·9	5·9	0·29	0·31
After 9 days	3·2	4·4	0·32	0·34
After 12 days	2·3	3·7	0·40	0·47

These results are of considerable interest. The total sugars immediately increase at the temperatures we are using and very much faster at the higher temperature. Then when the rotting becomes established there is a rapid reduction in the quantity present. The highest point reached at 36°C. corresponds with the commencement of the obvious rotting of the tuber. So far as the reducing sugars are concerned there seems a slow but steady increase during the exposure of the tubers, and this is more rapid at the higher temperature. The connection with the rotting is not however very obvious.

6. *Gummy Matter and Dextrin.*—The variation in the gummy materials which we have classed together under this head is very interesting and it seems more closely connected with the heat-rot than any constituent so far examined. The figures are as follows :—

	<i>Dextrin.</i>	
	Per cent.	Per cent.
Fresh Potatoes	1·1	1·1
After 3 days	0·93	0·84
After 6 days	0·93	1·3
After 9 days	1·1	2·4
After 12 days	1·3	3·5

After a preliminary fall in the amount of gummy matter at the beginning of storage, the increase in these constituents at the higher temperature is constant and substantial, while at the temperature below the rotting stage it is very small indeed. In the potatoes attacked with heat-rot the increase after six days is 18 per cent. after nine days it is 118 per cent. and after twelve days it is 218 per cent. while in those below the rotting temperature it never reaches more than 21 per cent.

From the preliminary results so far recorded, therefore, it is clear that among the constituents examined, the heat-rot is characterised by a marked increase in the ammoniacal nitrogen, by the increase in the total sugar, which afterwards declines, by a steady increase in the amount of reducing sugar to a greater extent than in potatoes kept below the rotting point, and by very large increase in the amount of those gummy substances which we have classed together.

These results were preliminary, however, as no special precautions were taken to exclude the action of surface fungi. The constituents just named were now determined in potatoes similarly kept, but which were first dipped in two per cent. copper sulphate solution, allowed to dry and then exposed to the temperatures required in open wire cages. The results under these conditions are shown by the following figures:—

1. *Total Nitrogen and Ammoniacal Nitrogen.*

	Total Nitrogen.		Ammoniacal Nitrogen.	
	Potatoes at 27°-30°C.	Potatoes at 36°C.	Potatoes at 27°-30°C.	Potatoes at 36°C.
	Per cent.	Per cent.	Per cent.	Per cent.
Fresh Potatoes	1·7	1·7	0·04	0·04
After 3 days	1·6	1·5	0·045	0·045
After 6 days	1·6	1·7	0·045	0·057
After 9 days	1·6	1·7	0·046	0·08
After 12 days	1·5	1·9	0·050	0·10

These figures confirm in a striking manner the results previously given. The total nitrogen does not alter, but the ammoniacal nitrogen rapidly increases at the rotting temperature while there is little rise at 27°-30°C. The proportion of rise at 36°C. is shown by the following figures :—

			Per cent.
(1) 3 days	..	..	12·5
(2) 6 "	..	..	42·5
(3) 9 "	..	..	100·0
(4) 12 "	..	..	150·0

2. *Forms of Sugar.*

	Total Sugar.		Reducing Sugar.	
	Potatoes at 27°-30°C.	Potatoes at 36°C.	Potatoes at 27°-30°C.	Potatoes at 36°C.
	Per cent.	Per cent.	Per cent.	Per cent.
Fresh Potatoes.	2·8	2·8	0·20	0·20
After 3 days ..	2·7	2·9	0·20	0·38
After 6 days ..	2·7	4·0	0·22	0·56
After 9 days ..	2·8	4·1	0·22	0·64
After 12 days..	2·8	4·1	0·25	0·72

The result here, where we have largely eliminated the possibility of surface fungal growth, is rather different from what we have seen before. Here there is a rapid rise in both the total sugar and in the reducing sugar, and in neither case does the amount again go down in the latter part of the experiment. The present figures probably represent more closely the real effect of the heat-rot, as the elimination of fungi has removed one of the chances of error. At the same time, it suggests itself as a possibility that the very slow increase of total sugar in the latter part of the test really

indicates that it is being formed and consumed at the same time, and that what we get is simply a figure which shows the excess of production over consumption or *vice versa*.

3. *Gummy Matter and Dextrin.*

	Potatoes at 27°-30°C.	Potatoes at 36°C.
	Per cent.	Per cent.
Fresh Potatoes	1·60	1·60
After 3 days	1·66	1·75
After 6 days	1·80	2·40
After 9 days	1·90	2·90
After 12 days	1·90	3·30

The figures here give results of the same order as those previously obtained. In the potatoes attacked with heat-rot the increase in gummy matter after six days is 50 per cent., after nine days it is 81 per cent., and in twelve days it is 106 per cent., while in those kept below the rotting temperature it never reaches more than 19 per cent.

So much for the actual materials in the potato. But the enzymes present may also be increased or diminished and it is possibly in the increased activity of these that the cause of the rotting lies. We therefore have determined the amount of two of the enzymes known to occur in the potato tuber, namely (1) catalase and (2) the oxidases. The tests were made with tubers which were protected by dipping in copper sulphate solution, from surface fungus attack, and were contained in sealed cylinders so that rotting took place in both cases, though it was more at the higher temperature.

1. *Catalase.*—The figures quoted represent the actual amount of oxygen given off by 2 grammes of potato pulp when placed in contact with a large excess of neutral hydrogen peroxide solution. The figures are, hence, comparative only. The experiment was allowed to continue for twenty-two days, when the high temperature potatoes were

completely rotten, and had probably been invaded by bacterial rots. The figures illustrate this point.

		<i>Catalase.</i>	
		Potatoes at 27°-30°C.	Potatoes at 36°C.
		cc. oxygen.	cc. oxygen.
Potatoes after 2 days	..	14·1	8·9
Do. 4 days	..	17·2	9·2
Do. 6 days	..	14·6	7·2
Do. 8 days	..	11·4	5·1
Do. 10 days	..	19·9	5·4
Do. 12 days	..	22·8	4·5
Do. 14 days	..	13·3	4·1
Do. 16 days	..	16·6	63·7
Do. 18 days	..	18·8	82·2
Do. 20 days	..	18·4	70·2
Do. 22 days	..	16·7	75·2

These figures show at 27° to 30°C. as great a constancy as can be expected in such a determination even after rotting has commenced. On the other hand at 36°C. they show (1) an immediate reduction in the amount of catalase as compared with the potatoes at the lower temperature, (2) a further gradual reduction until an exposure of fourteen days is reached, the amount going down until it is only about twenty-five per cent. of the average at the lower temperature, (3) a sudden and enormous increase after the fourteenth day till the end of the experiment. We are inclined to believe that this last rise has nothing directly to do with the 'heat-rot' process. The potato was soft and oozing before the fourteenth day, and we think (though we have no proof) that the later rise in amount of catalase is due to the entrance of bacteria. Apart from this the reduction in the amount of catalase at the higher temperature is very marked, and together with the increase in ammoniacal nitrogen, the rise in the sugar and in the gummy matter, forms the most striking chemical indication of the occurrence of the heat-rot in the potato tubers.

2. *Oxidase*.—The proportion of oxidase was measured by the amount of oxygen absorbed in four hours by pyrogallol solution mixed with 2 cc. of the potato juice. The figures in the following table therefore represent cubic centimeters of oxygen absorbed in four hours as a result of the activity of the oxidase on the quantity of potato juice mentioned :—

		<i>Oxidase.</i>	
		Potatoes at 27°-30°C.	Potatoes at 36°C.
		cc.	cc.
Fresh Potatoes	..	0·169	0·169
After 2 days	..	0·169	0·182
After 4 days	..	0·195	0·143
After 6 days	..	0·208	0·156
After 8 days	..	0·214	0·162
After 10 days	..	0·228	0·221
After 12 days	..	0·357	0·231

In both cases the exposure to the temperatures in question led to an increase in the amount of oxidase but the rise was considerably more rapid at 27° to 30°C. than at the higher temperature, where rotting was more rapid. It is evident that the measurement of this group of enzymes is not likely to be of use as an indicator of the progress of the development of 'heat-rot' in the tuber.

So far, therefore, as the heat-rotting of potato tubers in air is concerned, the following statement indicates how far each of the chemical changes which we have investigated appear to be associated with it :—

(1) the total soluble matter increases whenever the tubers are kept at a high temperature, but this increase does not appear to be a measure of the amount of rotting.

(2) the acidity is not affected by the rotting, while the alkalinity rises when the temperature is raised, but thereafter remains constant and is not affected by the degenerative changes going on.

(3) of the forms of nitrogen, only the ammoniacal nitrogen seems to be increased during the rotting process. This increases very rapidly, and the rise may amount to as much as 150 per cent. in twelve days.

(4) the sugars increase rapidly during the rotting of the tuber, but the total sugar seems to reach a maximum and there stop if it does not decline. The reducing sugars continue to rise at least until the heat-rot has penetrated the whole tuber.

(5) the gummy substances increase rapidly during the rotting process, the quantity reaching at least twice or three times the amount previously contained in the tuber. Where the temperature is not sufficiently high to induce rotting, very little increase in the quantity of these gummy matters occurs.

(6) the catalase is quickly reduced at the higher temperature when rapid rotting takes place and when the whole tuber has been invaded it only amounts to one quarter the quantity present in tubers kept at a lower temperature where rotting is relatively slow. When bacteria invade the rotting tissue, the catalase rapidly rises again.

(7) the oxidase group of enzymes rises in quantity when potatoes are exposed to a high temperature. It increases however more slowly when rapid rotting is taking place than if the temperature is only high enough to produce the degenerative changes very gradually.

*IV.—Chemical Changes accompanying Heat Rot
when air is excluded.*

The next point of interest was to ascertain how far the more important of the changes already described are affected by the exclusion of air, or in fact by the prevention of any respiration of the tubers. This was secured in two

ways. Either the tubers were (after destroying fungi on the surface by dipping in a two per cent. solution of copper sulphate and allowing to dry) dipped in collodion, or else they were coated with melted paraffin wax at a temperature between 40° and 50°C. Both these methods seal the surface from any respiratory exchange, but the collodion injures the eye buds at once, while the paraffin wax does not directly do so. The latter method was, therefore, preferable for the present inquiry, but we will give the figures obtained in each case. The potatoes protected by collodion were exposed in wire cages, and will be dealt with first. In this case rotting took place within twelve days at both the experimental temperatures, though of course it was more rapid at the higher.

1. *Total Nitrogen and Ammoniacal Nitrogen.*

	<i>Total Nitrogen</i>		<i>Ammoniacal Nitrogen:</i>	
	Potatoes at 27°-30°C.	Potatoes at 36°C.	Potatoes at 27°-30°C.	Potatoes at 36°C.
	Per cent.	Per cent.	Per cent.	Per cent.
Fresh Potatoes	1·70	1·70	0·040	0·040
After 3 days	1·68	1·60	0·043	0·050
„ 6 „	1·62	1·64	0·050	0·050
„ 9 „	1·62	1·64	0·048	0·052
„ 12 „	1·66	1·65	0·052	0·068

We have here, therefore, as would be expected, no increase or decrease in the total nitrogen, and the gain in ammoniacal nitrogen at the higher temperature is proportionately less than occurred in air. The actual increase was as follows, in twelve days.

Percentage increase at 27° to 30°C.	30 per cent
Percentage increase at 36°C	70 per cent,

2. *Forms of Sugar.*

	<i>Total Sugars.</i>		<i>Reducing Sugars.</i>	
	Potatoes at 27°-30°C.	Potatoes at 36°C.	Potatoes at 27°-30°C.	Potatoes at 36°C.
	Per cent.	Per cent.	Per cent.	Per cent.
Fresh potatoes ..	2·80	2·80	0·20	0·20
After 3 days	2·80	2·80	0·21	0·21
„ 6 „	2·88	3·20	0·20	0·31
„ 9 „	2·80	3·20	0·20	0·50
„ 12 „	2·80	3·40	0·22	0·57

We have here a result which almost seems to indicate that the formation of sugars is not an essential part of the heat-rot, which seems to be capable of taking place without any considerable increase in their amount. At the higher temperature sugars are certainly formed, but it is difficult to consider their increase as being directly connected with the rotting process. At the lower temperature rotting was taking place after the sixth day, but no increase in the sugars is recorded.

3. *Gummy Matter and Dextrin.*

	<i>Gummy Matters.</i>	
	Potatoes at 27° to 30°C.	Potatoes at 36°C.
	Per cent.	Per cent.
Fresh potatoes	1·60	1·60
After 3 days	1·05	1·14
„ 6 „	2·00	2·70
„ 9 „	2·30	3·60
„ 12 „	3·00	3·10

This result must be interpreted in the light of the fact that when air is excluded as in the present case, the heat-rot takes place at a much lower temperature than in the case with air, and that after six days rotting is taking place at 27° to

30°C. as well as at 36°C. The association of the increase of gummy matters with the rotting seems clear and is very striking.

In our experiments in which air was excluded by means of paraffin wax, the potatoes were stored in sealed glass cylinders, and so the rotting was easily obtained at the lower temperature of experiment. The actual history of the potatoes at the two temperatures of exposure in this case may be indicated.

At 36°C. even on the first day some slight depressions on the surface were noticed, which had extended a day later. Some swelling of the paraffin layer were noticed as water tended to accumulate in drops below it. By the next day on cutting the potatoes the surface layer of the flesh appeared pink, starting apparently from the eyes. The same outside signs continued, and on the sixth day when the potatoes were cut the surface layer was reddish brown, and some of the eyes were black. A small cavity had formed at the centre of one potato. After this the colour of the skin became rapidly black, and on the ninth day, the flesh under the skin was greyish black, but darker at the stalk and at the eyes. The tubers were quite soft at the eyes. On the twelfth day practically the whole of the flesh was greyish or reddish black and the tuber was quite soft.

At 27°C. to 30°C. though slight depressions formed on the surface of the tubers no pinkish colour was observed on cutting on the third day. No swellings were observed in the paraffin. On the sixth day the flesh below the surface was pinkish in certain cases, but had already become greyish black at the eyes. This was not by any means general, and even by the twelfth day only some of the potatoes were slightly rotting, especially at the stem, where there was a tendency to become soft and greyish black,

The chemical examination of the tubers gave results as follows :—

1. *Forms of Nitrogen.*

	<i>Total Nitrogen.</i>		<i>Ammoniacal Nitrogen.</i>	
	Potatoes at 27° to 30°C.	Potatoes at 36°C.	Potatoes at 27° to 30°C.	Potatoes at 36°C.
	Per cent.	Per cent.	Per cent.	Per cent.
Fresh potatoes ..	1·60	1·60	0·040	0·040
After 3 days ..	1·60	1·62	0·037	0·036
" 6 " ..	1·70	1·70	0·040	0·047
" 9 " ..	1·80	1·60	0·045	0·050
" 12 " ..	1·70	1·68	0·045	0·053

The increase in ammoniacal nitrogen in the rotting potatoes is again much less than occurred in air. The actual increase in twelve days was as follows :—

		Per cent.
Percentage increase at	27° to 30°C.	.. 12·5
Do. do. at	36°C.	... 32·5

2. *Forms of Sugar.*

	<i>Total Sugars.]</i>		<i>Reducing Sugars.</i>	
	Potatoes at 27°-30°C.	Potatoes at 36°C.	Potatoes at 27°-30°C.	Potatoes at 36°C.
	Per cent.	Per cent.	Per cent.	Per cent.
Fresh potatoes ..	2·10	2·10	0·24	0·24
After 3 days ..	2·32	2·40	0·24	0·24
" 6 " ..	2·68	2·66	0·30	0·34
" 9 " ..	2·40	2·41	0·37	0·38
" 12 " ..	2·60	2·50	0·37	0·29

These results confirm what has been already stated as a result of the examination of potatoes treated with collodion. It is difficult to consider the increase in total sugars, or even the increase in reducing sugars, as an essential part of the rotting process. It accompanies it certainly in certain cases, but the rotting seems to be capable of taking place without

materially greater increase in the sugars than occurs when the rot is very limited as in the tubers kept at the lower temperature in the present case.

3. *Gummy Matter and Dextrin.*

	<i>Gummy Matters.</i>	
	Potatoes at 27° to 30° C.	Potatoes at 36° C.
	Per cent.	Per cent.
Fresh potatoes	.. 1·00	1·00
After 3 days	.. 1·10	1·40
„ 6 „	.. 2·10	2·50
„ 9 „	.. 2·20	1·10
„ 12 „	.. 2·80	2·20

In this case we get a curious result which does not seem, for the time being, capable of explanation. It shows the rise in the amount of gummy matter when we have learnt to associate with heat rot. It shows also the fairly large rise in the preliminary stages of rotting reached at the lower temperature in twelve days. There is an inexplicable fall in the gummy matter in the later stages of the exposure at 36°C. which demands further study and investigation.

Taken generally, these experiments with potatoes in which air is excluded by covering the surface of the tubers with an impervious layer it may be said that—

- (1) the increase in ammoniacal nitrogen is much slower than when the potatoes rot in the presence of air and the more completely the air is excluded, the less is the rise in this constituent.
- (2) the total sugars as well as the reducing sugar tend to increase when the potatoes are exposed to high temperatures in the absence as well as in the presence of air. It is difficult however to connect this increase directly with the rotting process.

(3) the gummy matters increase during rotting in the absence of air as well as in its presence, but the increase is slower. The association of this increase with the rotting seems very clear.

V.—Chemical Changes accompanying Heat-Rot in Carbon Dioxide and Nitrogen.

Carbon Dioxide.—During the storage of potatoes in heaps, or bags, the atmosphere round the tubers gradually tends to become more and more charged with carbon dioxide, as a result of the respiration of the tubers. As these are the conditions under which heat-rot usually becomes serious, it was interesting therefore to consider the chemical changes which would be found taking place when potatoes were placed in pure carbon dioxide. The potatoes had in this case of course to be kept in sealed jars.

The actual changes in the appearance of the potatoes so stored differ little from those already described as occurring when the surface of the tubers are sealed with paraffin wax. The rotting follows similar lines and is certainly not any more rapid than in the previous case. At 27°C. to 30°C. rotting had started before the twelfth day, the portion of the flesh immediately under the skin being greyish black.

The figures obtained in the usual determinations are as follows :—

1. *Total Nitrogen and Ammoniacal Nitrogen.*

	<i>Total Nitrogen.</i>		<i>Ammoniacal Nitrogen.</i>	
	Potatoes at 27°-30°C. Per cent.	Potatoes at 36°C. Per cent.	Potatoes at 27°-30°C. Per cent.	Potatoes at 36°C. Per cent.
Fresh potatoes ..	1·60	1·60	0·037	0·037
After 3 days ..	1·60	1·68	0·036	0·039
" 6 " ..	1·60	1·70	0·050	0·052
" 9 " ..	1·68	1·70	0·050	0·054
" 12 " ..	1·64	1·70	0·054	0·067

The changes indicated by the increase in ammoniacal nitrogen evidently are taking place at the lower temperature

though more slowly than at the higher. The close connection between this increase and the phenomena we are investigating is again obvious. The amount of ammoniacal nitrogen formed is again less than in air, but very similar to that produced when this latter is excluded.

2. *Forms of Sugar.*

	<i>Total Sugar.</i>		<i>Reducing Sugar.</i>	
	Potatoes at 27°-30°C.	Potatoes at 36°C.	Potatoes at 27°-30°C.	Potatoes at 36°C.
	Per cent.	Per cent.	Per cent.	Per cent.
Fresh potatoes ..	2·10	2·10	0·20	0·20
After 3 days ..	2·40	2·90	0·20	0·22
" 6 " ..	2·90	3·10	0·24	0·24
" 9 " ..	2·90	3·00	0·24	0·24
" 12 " ..	3·00	3·10	0·23	0·26

The similarity at the two temperatures investigated is again very marked. The increases of sugar in either case, however, are far less than we have obtained in the air, but are comparable with those obtained in the cases where respiration was prevented, at any rate so far as the rise in the quantity of total sugars is concerned. The increase in the amount of reducing sugars is, however, less than in this case. All the results certainly support the suggestion that the changes in sugar noted are rather part of the ordinary respiration of the potatoes at the temperatures involved, than connected with the specific question of rotting.

3. *Gummy Matters and Dextrin.*

	<i>Gummy Matters.</i>	
	Potatoes at 27° to 30°C.	Potatoes at 36°C.
	Per cent.	Per cent.
Fresh potatoes ..	1·00	1·00
After 3 days ..	1·20	1·18
" 6 " ..	3·00	2·50
" 9 " ..	2·20	2·50
" 12 " ..	1·60(?)	2·20

Here again, with a certain amount of variation, we see a result somewhat similar to that obtained when the surface

of the potatoes was sealed up with paraffin wax. In the absence of air, there seems to be an initial rise in the gummy matter when rotting begins, which in this case tends to fall later on. This fall, after the rotting is fully established, is peculiar to these cases when air is excluded. The general conclusion as to the connection of the increase in gummy matter with the rotting is, however, clear. Its later diminution is evidently a secondary reaction whose rationale needs further investigation.

Nitrogen.—If the atmosphere of carbon dioxide in the sealed jars be replaced by nitrogen, we get a condition of things in which the changes in the potatoes can hardly be directly influenced by the surrounding medium. When potatoes were put into sealed jars in nitrogen at the usual temperatures, the rotting changes at 36°C. showed almost the same course as in carbon dioxide and the tubers are quite soft and rotten on the twelfth day. At 27° to 30°C. the changes were much slower than in carbon dioxide. After six days the tubers were quite sound, and it was only after twelve days that any very considerable amount of rot had developed.

The principal difference between this case and those recorded previously is the relatively very small chemical changes which have occurred. The following figures will show this :—

1. *Total Nitrogen and Ammoniacal Nitrogen.*

	<i>Total Nitrogen.</i>		<i>Ammoniacal Nitrogen.</i>	
	Potatoes at 27° to 30°C. Per cent.	Potatoes at 36°C. Per cent.	Potatoes at 27° to 30°C. Per cent.	Potatoes at 36°C. Per cent.
Fresh potatoes ..	1·80	1·80	0·050	0·050
After 3 days ..	1·80	1·80	0·060	0·060
" 6 " ..	1·70	1·80	0·062	0·061
" 9 " ..	1·73	1·82	0·059	0·060
" 12 " ..	1·80	1·80	0·067	0·080

The increase in the ammoniacal nitrogen in twelve days is 34 per cent. at 27° to 30°C. and 60 per cent. at 36°C. This increase, though small relatively to what occurs in air, is comparable with that obtained when tubers are sealed with collodion, and greater than when they are closed with paraffin wax.

2. *Forms of Sugar.*

	<i>Total Sugars.</i>		<i>Reducing Sugars.</i>	
	Potatoes at 27° to 30°C.	Potatoes at 36°C.	Potatoes at 27°-30°C.	Potatoes at 36°C.
	Per cent.	Per cent.	Per cent.	Per cent.
Fresh potatoes ..	2·2 ¹	2·2	0·25	0·25
After 3 days ..	2·3	2·4	0·25	0·26
„ 6 „ ..	2·1	2·2	0·25	0·26
„ 9 „ ..	2·2	2·3	0·27	0·26
„ 12 „ ..	2·1	2·4	0·26	0·25

Here the changes are very small, and confirms what has been said before with regard to the non-connection of the increase of sugar with the rotting process. As no respiration can take place, no increase of sugar of any kind is noticed, in spite of the fact that active rotting of the tubers is in progress.

3. *Gummy Matter and Dextrin.*

	<i>Gummy Matter.</i>	
	Potatoes at 27° to 30°C.	Potatoes at 36°C.
	Per cent.	Per cent.
Fresh potatoes ..	0·90	0·90
After 3 days ..	1·30	1·35
„ 6 „ ..	1·40	0·98
„ 9 „ ..	1·50	1·10
„ 12 „ ..	2·80	1·80

The changes in this matter are very irregular, and it is difficult to understand their course particularly at the higher temperature. But the final result both at the

higher and at the lower temperature is that the proportion of gummy matters has doubled during the course of the exposure.

The consideration of these results of exposure of potatoes to a rotting temperature in an atmosphere of carbon dioxide or nitrogen does not lead to any modification of the conclusions reached at the end of the previous section. In these cases, just as those in which the potatoes were kept isolated from all respiratory interchange by being sealed with collodion or with paraffin wax, the increase in ammoniacal nitrogen was very much less than during rotting in air. It was still however substantial, amounting in twelve days to from 60 to 90 per cent. of the original quantity at the higher temperature. The increase of the sugars is very much less than in air, especially when the potatoes are exposed in nitrogen. The conclusion seems confirmed therefore that the large increases noted when the tubers are exposed in air are rather the result of the ordinary respiration of the potato at the high temperature of the rotting process than connected specifically with the rotting process itself. As regards the gummy matter, its increase during the rotting process, and as a result of that process, seems very clear.

VI.—The Respiration of Potatoes at the Rotting Temperature.

One more question remained. Is the rotting described closely and clearly connected with any marked increase in the production of carbon dioxide by the potato tuber? Even at low temperatures, carbon dioxide is being continually produced when potatoes are stored, but the respiration, of which this production is the evidence, is very slow. It becomes more rapid at higher temperatures and experiments were undertaken to see how far this respiration was affected by the rotting which occurs under the influence of high temperature.

The method adopted was to put the potatoes in sealed glass jars in air, as in previous experiments. Then the jar with the contained potatoes was exposed to the temperatures of 36°C. and 27° to 30°C. respectively for varying periods of time. Then the air in the jars was drawn out with an aspirator and replaced by fresh air free from carbon dioxide and the whole allowed to stand for one day in the laboratory. The air was then again extracted and the carbon dioxide in it determined by absorption in caustic potash in the usual way. In this manner the carbon dioxide formed in 24 hours after exposure to the temperatures above named for two, four, six, eight, ten and twelve days respectively was determined.

The rotting in this case took place to an extent almost exactly similar to that which occurred in the experiment previously described when the potatoes were dipped in paraffin wax.

The results obtained were as follows, the amounts of carbon dioxide produced being calculated per 100 grammes of fresh potatoes :—

Length of exposure.		(1)	(2)
		After exposure at 27° to 30°C.	After exposure at 36°C.
		Grammes.	Grammes.
Fresh potatoes	..	0·050	0·050
After 2 days	..	0·053	0·081
„ 4 „	..	0·088	0·071
„ 6 „	..	0·094	0·072
„ 8 „	..	0·081	0·055
„ 10 „	..	0·078	0·038
„ 12 „	..	0·074	0·035

These results are of great interest. In both cases the exposure of the potatoes to a high temperature caused an immediate increase in the respiratory activity of the tuber. At the higher temperature, however, when rotting supervened

very quickly, there was a very rapid reduction in the amount of carbon dioxide formed when the potatoes were again placed at ordinary temperature. After exposure for twelve days the respiration had fallen to a much lower figure than before being placed at the higher temperature.

When exposed at the temperature of 27° to 30°C. the potatoes were little affected for two days ; after this the activity rapidly increased, but as the rotting became more marked the quantity of carbon dioxide produced in the time noted fell. The amount of rotting was only limited even to the end of the exposure, and the respiratory activity was still much greater than before exposure to the temperature in question.

It is evident that as soon as rotting supervenes, the amount of carbon dioxide becomes less, which is an evidence of the decrease of the respiratory activity of the potato. When the rotting is general, and the eyes are killed, the amount of carbon dioxide produced is very small indeed.

VII.—General Conclusions.

The course of heat-rot of potatoes, produced when the tubers are stored at a high temperature (above 30°C.), especially in the absence of thorough aeration, is associated with (1) a considerable increase in the ammonical nitrogen in the tuber and (2) an increase in the amount of gummy matter and dextrin contained in the potato juice. The process in connection with these two constituents takes place whether the rotting occurs in air, or when the potatoes are kept in an atmosphere of carbon dioxide or nitrogen, or when all respiratory exchange is prevented by dipping the tubers in collodion or in paraffin wax. In air, in addition, there is a considerable increase in the amount of sugars, but this increase is much lower when respiration is prevented, and it is probable that it is not connected with the rotting process.

The rotting is not accompanied by any material increase in acidity or alkalinity of the juice of the tubers, but when

the rotting is marked the amount of the enzyme catalase, is very much reduced, until the process is complete and the potato completely soft or rotten. The rotting produced by heat seems to result in a considerable decrease in the respiration of the tuber, as measured by the amount of carbon dioxide produced by potatoes which have been exposed to the temperatures involved.

The primary purpose of these experiments, namely to find a method of detecting, by chemical means, the first onset of heat rotting in potatoes, has not been achieved, but the results obtained appear to be of considerable interest nevertheless, and to indicate clearly something of the character of the changes involved in the process studied.

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Department of Agriculture, Bombay

BULLETIN No. 99 OF 1920

**RICE CULTIVATION IN THE LARKHANA
DISTRICT, SIND**

(A PRELIMINARY SURVEY)

BY

ABDUL REHMAN ISHAQ, L.Ag.,

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RICE CULTIVATION IN THE LARKANA DISTRICT.

A PRELIMINARY SURVEY.

Among all the products of the Larkana District in Sind, rice occupies the chief place. The area under rice each year is between three hundred thousand and three hundred and fifty thousand acres, which represents nearly fifty per cent. of the total cultivation in the *kharif* season. The main rice area stretches along a low-lying belt of land between the river Indus on the east and the tableland of the Kohistan range on the west, and from Khairpur Nathanshah in the south to Ratodero in the north. It is very intensively grown in the portion of the country known as *Mail*, comprising adjacent portions of the talukas of Kamber, Larkana, Warah and Dokri. The tract south of Khairpur Nathanshah known as *Maha* also contains extensive areas under rice, but the cultivation is much inferior.

RICE SOILS OF LARKANA.

The rice lands of the tract are clay or clay loam varying greatly in texture from hard impervious clay very difficult to work to soft porous easily workable loam. A general survey of the tract will show it to be divided into three main divisions of soil, their lengths running from north to south. The river side belt about 10 miles wide is clay impregnated more or less with salts. The central belt is clay loam about five miles broad, and a submontane strip, also about five miles wide, is soft clay loam deficient in humus. There is, however, no marked line of demarcation between the three belts, their texture gradually passing from hard clay of the riverside belt to poor clay loam on the side of the hilly tableland. Here and there we find some distinct variations in the width of each of the strips. For example, the north-west

portion of Procha in Mehar which is topographically in the riverside belt is a good retentive soil, containing a good deal of humus and maintains a crop of the quality unusual in this strip. In other places where the surrounding areas are loamy clays, a piece is often found, which by virtue of its low-lying position is hard, clayey and containing salt. Some portions of Gulkalhoru in Mirokhan were observed to be of this texture. Several such portions were observed not to be similar to the greater part of the soils on their own belt. This condition has been brought about by unequal intensity of cultivation occasioned by differences in water supply, as there appeared little evidence of any other factor leading toward their being deficient from surrounding areas. Their appearance brings out in a most striking manner how irrigation is an important influence on the physical condition of the soils.

The riverside belt generally supports a first class crop, the central much less and a tract commanded by the tail of canals rarely any. Sometimes even in the first two belts the hygroscopic conditions or the level, the adhesiveness or the retentiveness of certain portions appear to modify greatly their capacity for growing the crop. Deh Dhamrao, on the north of the canal of the same name, was practically bare of any "*dubari* crop". The soil has been put under cultivation of recent years, therefore sufficient vegetable matter has not collected in it to make it retentive of moisture. Portion of Deh Mahmadi Tanwary in Mirokhan also did not support *dubari*, on account, I think, of its deficient water capacity. The landscape presents no variety. The few mounds or depressions that exist are of inappreciable size, except a few lakes round about Kamber.

CLIMATE OF THE RICE TRACTS.

It is hot and dry from May to September, which forms the best weather. The period from May 12th to June 20th

is called *Challiho* (*lit.* forty days), during which strong hot winds and dust-storms blow. From July 1st to the end of September there is generally a want of fresh breeze and the nights are generally close. The *Sarao* or autumn begins with October and ends in December, when it is damp, and malaria prevails due to accumulation of water round about. From December to February it is cold and chilly and this which forms the winter. Malarial fevers, bronchial coughs and colds are prevalent through the *Sarao* season and sometimes continue well into the winter. The spring (*Bahar*) season which sets in in March and lasts up to April is moderate and pleasant when there is general immunity from disease. The tract is free from plague, and cholera is scarce. In the hot months if a breeze occurs it is from the south, in winter the wind blows from the north. East and west winds also blow occasionally. The former is considered beneficial and the latter prejudicial to grain formation if they happen to come at the flowering season of the rice crop. Rainfall is insignificant and is not wanted in the *kharif* season. Its want is generally felt during January when it proves of the utmost benefit for the *rabi* crop. The growth of rice cultivation has been vigorous during last two decades but the increase in population which was taking place during the first decade has been going down throughout the years of the last decade. The most serious malady in the tract is malaria which sometimes delays very important harvest operations,

IRRIGATION.

The irrigation sources of the tract are the Sukkur Canal, the Gharwah and the Western Nara Canal and their branches. They all run approximately from east to west and traversing the rice tract, end in the semi-sandy plateau. The main canals are opened between May 15th to 25th and their branches

flow by the first week in June. All the three are the most important inundation canals from the river and the tract is densely covered with their ramifications, all enjoying flow water. These canals are big old works and have continued to exhibit a very good record of their water supply. Owing to their good depth, some water remains in them during winter too which is lifted up for irrigating gardens, wheat or other winter crop along their banks. With the growth of rice cultivation and as a precaution against vagaries of the river, many improvements have been made in these works by cutting out new heads from the river, clearance of silt, building of dams, and regulators and strengthening embankments for the benefit of the higher lands. With these improvements the area under rice has nearly trebled during the last twenty years and much waste has been reclaimed and brought under cultivation. While the main canals have been maintaining their excellence, limited by the quality of inundation their off-takes are not all equal, so far as supply of flow water is concerned. The deficiency is, however, remedied by fixing rotations or by converting rice areas into land for *jowar* or *bosi* wheat. Usually much of the water is absorbed by lands nearer the mouth of these distributaries and those nearer the tail suffers specially from any deficiency that may occur. The tail areas are further subject to another disadvantage in that their water requirements being synchronous with those of the head lands, the rotation in their case is of little use and when the head lands have had their requirements met their owners let down much of the water held up before, which sometimes submerges the tail areas, and these consequently suffer not only from initial deficiency, but also from the untimely abundance. This difficulty is all the more aggravated in view of the fact that there is very little waste land on which to turn off the surplus water. These old canal systems are not yet so well harnessed as some of the recent ones, like the Jamrao, by innumerable regulators and escape channels. The sketch map attached to this

bulletin shows roughly how the irrigation is distributed in the rice tract. From the canal branches, take off the *zamin-dari karias*, every big *zamindar* possessing a separate outlet from the branches. His cultivators then cut up the *karia* in several places and let water into their own portions of cultivation. There are no convenient small water channels to water each field separately, but the water runs from higher plots to lower ones through intervening *bannas* or embankments.

CULTIVATION.

The rice is invariably sown on the transplanting system. When the canals begin to flow the seed beds which are generally a *guntha* (one-fortieth of an acre) each in area are prepared in the following way:—

The bed is levelled and scraped of its grass, etc., with a *kodai* (spade). The surface is packed and smoothed and the *bannas* repaired. Since every year the same beds are utilized there is little labour required for this annually. Then a layer about two inches thick of cowdung is evenly spread with a rake and packed and beaten *down* with its head piece. Wherever there is scarcity of this material it is supplemented by a six-inch layer of paddy straw or a three-inch layer of grain husk got from the mills. Cowdung always forms the top layer when used in conjunction with any of these. Sometimes straw or husk is alone used in which case about a ten-inch layer of straw or a six-inch layer of husk is considered sufficient. Whether the effects of different *rab* materials is identical or not, the *haris*' (or cultivators') opinion is divided but they always prefer cowdung to other materials by custom, and for Sugdassi rice they always procure the former. I think there is an argument in favour of cowdung. This burns slowly and radiates more heat so that the temperature necessary to bring about the maximum beneficial result is easily acquired by this fuel. Whereas straw and husk may partly

fail in producing this desirable effect owing to the one being too quickly combustible and the other giving out less radiant heat. As already worked out elsewhere, it is not the ash or other mineral matter resulting from *rab* burning that counts for fertility so much as the heat which is generated in the process and which improves the physical texture of the seed bed. It may be of interest to note that the cultivator from experience prefers a hard nursery bed in contradiction to a pulverised surface, the idea being that the roots of seedlings should not be deeply embedded in the soil and be subsequently difficult to pluck out or be liable to injury in the action. There is another advantage *too* underlying this practice. The roots, unable to penetrate the hardened surface, freely develop in the soft ash above, and so the growth of seedlings becomes more rapid, it has been found that quickly grown seedlings give better results in the field, for the crop ripens later in proportion as to the age of the seedlings is more advanced, as they then form joints and do not tiller. The Philippine method of preparing seedlings had been devised chiefly with this object in view.

Seedlings.—A day before sowing the beds fire is applied to the manure, preferably at noon by spreading over it burning cinders which ignite the bed simultaneously all over. In about a couple of hours the manure completely burns away. Next morning seed is broadcasted over it at the rate of one to one and a half *kassas** for a bed of about $\frac{3}{4}$ *guntha*. The water is immediately let in, a man constantly tapping down, with a bushy branch, the seed from floating on the water. In this process the wet ash covers the seed and weighs it down. The nursery bed is watered every day so as just to cover the surface. After a couple of days the seed germinates, after which watering is given every second or third day, till they are fifteen to twenty days old when they are ready for transplanting. Some pluck them dry if the bed is soft. Otherwise

* The *kassa* is a measure and the grain in it weighs 26 pounds.

they fill the bed with water and pluck in standing water carefully washing off all earth attached to the roots. The seedlings are made into bundles weighing approximately one pound and containing from five to eight hundred plantlets. The period of raising seedlings lasts for little less than two months beginning from June 1st. Correspondingly the transplanting also goes on for about two months and *Thadhri* or *Gokal Ashtami* (about the second week in August) is considered the latest day for the operation.

Preparation of field.—There are two methods of preparing land for transplanting, (1) puddling just at the time of transplanting, (2) ploughing after harvest once or twice when the land is moist enough. There are soils which respond to puddling much greater and other which produce good results with winter ploughing but puddling generally is said to have a deleterious effect on the *dubari* crop. Puddling is resorted to in case of hard clayey soil where there is too much weed growth, or on soils which soon dry out and set too hard after the harvest for the plough to break them. Ploughing the land in winter is more beneficial than puddling and where circumstances of moisture, cattle and labour are favourable this is invariably done. In the puddling system water is allowed in the field and when it has well soaked into it and softened it and some remains still on the surface, the soil is ploughed and cross-ploughed. Immediately after, a light plank is rolled over, which buries in the mud all grass and smooths the surface. In winter-ploughed lands no further treatment is given except repairing the *bannas* (embankments).

Transplanting.—The water is then allowed in the fields and the works of transplantation commenced. This operation is generally done by the *Machhi* or *Sheikh* castes on contract at the rate of Rs. 1-8-0 to Rs. 2-0-0 per *jireb* (half an acre). At the same time as the seedlings are plucked, bundled and brought in headloads to the field, the transplanters

hold a bundle each in the left hand, and with the right separate a bunch of six to twenty fair plantlets and force, with their thumb and forefingers, their roots into the soil. Some operators are very dexterous and can earn about 12 annas a day each. About five hundred bundles are needed to plant a *jireb*. The operation is undertaken during the morning only between 7 a.m. and 12 noon. The tops of the older seedlings are snapped away to reduce evaporation from their leaves. It is a belief among the cultivators, that the younger seedlings take root earlier and their original leaves continue on, whereas in older ones the lateral leaves die away, and it is a long time before new ones shoot out. The younger plants tiller much more than the older ones. Seedlings should be plucked before any internode is developed on their stems. In practice, the number of seedlings sown in a bunch varies with their length from six to twenty. The bigger the plantlets the smaller the number in a bunch and *vice versa*.

Watering.—After transplanting water is let in from the channels and allowed to remain in each plot, the area of which varies according to the surface contours. In uneven ground they may contain as little as one to two *gunthas*, but in usual plains they are not more than ten to fifteen *gunthas* in area. In the beginning water is used carefully till the seedlings take root but in the later period of their growth, the *hari* lets in as much water as the embankments can hold. They are generally from nine to fifteen inches high. The *hari* prefers a small quantity of water always flowing in the rice field afterwards. Beyond taking out weeds once or twice there is no other attention paid to the crop and one man is sufficient to keep off stray animals and attend to the watering of about fifteen acres. In certain soils the vegetative growth of paddy is almost rank. In such cultivation the *hari* allows his cattle to graze off paddy tops above water and sometimes he cuts them with a sickle. This pruning encourages the formation

of bigger earheads and keeps down the proportion of straw to grain.

Harvesting.—The crop is ready by the end of October. Four men or six women can cut a *jireb* per day, but if the land is too wet it takes six men or ten women for the job. If the operation is got done by contract by outside labour the wages are paid in kind from $1\frac{1}{2}$ *kassas* to 3 *kassas* per *jireb* cut with a liberal allowance of straw to feed their cattle during the period of engagement. The harvest extends over one month and a half chiefly owing to different varieties maturing at different times, the earliest being *Sigro* and latest *Sugdassi*. As the crop is cut it is kept on the field to dry for a couple of days and then removed in headloads to the threshing yard.

Threshing.—One threshing yard is common to all the *haris* of the same *zamindar* or of the same village, every *hari* looking after his own stack. The cut crop is arranged in big cylindrical stacks each of which represents a separate cultivator's crop, or the produce of one survey number. The threshing is done, as with all other crops, under the feet of cattle. A hard piece of ground is selected levelled with the *kodol* (spade) and mud plaster applied if the soil surface is soft. Generally a team of four or five cattle are made to tread out paddy by walking over a circular heap. Paddy grain easily separates from the straw and, unlike wheat, as the grain of each charge separates, the straw is removed to one side with a wooden fork and a new charge is added on to the heap until the whole stock is finished up this way. Then the grain with the fine straw or chaff is heaped up and kept for winnowing and the paddy straw made into headloads or bound into big cylindrical rolls. The threshing is generally started at 10 a.m. and the day's work is over by about 4 p.m. Four cattle with a man and a boy can thresh out a maund (82 pounds) of grain per hour if the fork man deftly works the crop up and down, because it is his work that

counts much in paddy threshing. *The Prong* variety is a bit difficult in threshing in comparison with other varieties. The straw rolls are very neatly bound and were it not for their big size they would compare very favourably with any machine made bale in other respects. The binding straps are twisted out from the straw and laid flat on the ground about a foot apart and straw evenly spread over them. Three men hold the ends of these straps one side and roll the straw between them, all the time pressing down the stuff with the feet and hand and after bundling they knot the free ends of the straps. Each roll weighs about three to four maunds and will fill one whole cart.

Winnowing.—This is done in the usual way when the wind blows. With a good breeze one man can clean out twenty maunds of grain in a day of eight hours. The threshing season lasts for nearly two months, being sometimes protracted even longer for considerations of *dubari* operations and winter ploughing. As soon as the grain is cleaned it is collected and made into conical heaps and the *zamindar* puts a stamp mark on it to protect it from being tampered with till the *batai* or sharing time.

Outturn.—The yield per *jireb* varies considerably with the variety, date of sowing, nature of soil, and irrigation conditions from 15 to 50 *kassas* (Kassa = 26 lbs.) and about 15 to 40 bundles of straw weighing about 40 lbs. each. After *batai* (division of produce), such portion as is required for meeting any liability is sold off to the *bania* (grain dealer), and the remaining is stored in mud bins for seed or home consumption.

Mud Bins.—These are of two kinds, one is higher and moveable, of two to ten maunds capacity, and this sort is made entirely of mud. It is cylindrical in shape with an immovable lid on the top from which it is filled. It has a small port near the bottom whence the grain is taken out as required. This sort of bin is called *gundi*. The other

storage receptacle is called *palli*, and is constructed in the following manner. About six pillars about two feet high are constructed of bricks, one to three feet apart, according to the desired capacity of the *palli*. Over these wooden rafters and matting are placed to make a circular platform. Then wooden poles six to ten feet long are driven upright round the edge of this platform. Inside and over the platform a strong matting woven of *Lai* (*Tamarix gallica*, Linn.) twigs of such dimensions as will round and act as a wall inside the upright poles and when the grain is poured from the top it rests against them. The poles are further fastened to each other by locking ropes round them. In the centre of the platform a pole about twelve feet long is inserted, the top end of which supports the conical or dome-like roof. Then the whole structure is mud plastered all round. The capacity of such a *palli* is from twelve to twenty *kharar* of 20 maunds each. If the grain is stored in them before being perfectly dry it moulds and is spoiled.

PROFIT AND LOSS OF RICE CULTIVATION.

The subjoined table details the expenses and income from rice cultivation for 1917. In making this estimate average conditions of crop production have been taken into account, *viz.*, average good soil, fair inundation, immunity from wholesale disease, normal charges of labour supply, second class assessment, undisturbed markets and the common paddy variety. Expenses of weeding are not taken into account as the price of grass taken out more than balances them.

Expenditure per jireb ($\frac{1}{2}$ acre).

			Rs.	a.	p.
Preparing seed bed	..	..	0	6	0
Cost of two carts of manure	..	..	1	0	0

	Rs.	a.	p.
Cost of seed, 1½ <i>kassa</i>	1	8	0
Puddling and ploughing (man and a pair) ..	1	0	0
Transplanting on contract	2	0	0
Watching and watering, 1 man for 2 months at 10 p. m. for 30 <i>jireb</i>	0	10	8
Harvesting price of two <i>kassas</i> of grain ..	2	0	0
Bundling, carrying and stacking in yard ..	1	0	0
Threshing and winnowing crop of 20 <i>kassas</i> ..	2	2	0
4 cattle = Re. 1, 2 men = Re. 1 and 1 boy = Annas 2.			
Miscellaneous expenses of marketing, etc. ..	0	2	4
Irrigation and land assessment at Rs. 4-8-0 per acre	2	4	0
<i>Karia</i> clearance	0	4	0
Total expenses ..	14	5	0

Receipts per jireb (½ acre).

	Rs.	a.	p.
Paddy grain, 20 <i>kassas</i> at 50 <i>kharar</i>	16	10	8
Paddy straw, 20 bundles at 4 annas a bundle ..	5	0	0
Total receipts ..	21	10	8
<i>Deduct</i> expenses ..	14	5	0
Net profit ..	7	5	8

The net profit herein worked out will be fully interpreted under *batai* (*vide infra*).

RICE VARIETIES.

There are a good many varieties in cultivation in the district and if a careful and systematic classification were undertaken the number known will probably be largely increased. The cultivators have come to recognise merely those

that the trade classifies as distinct. The latter differentiates them according to their commercial value with the consequence that a good many botanically different varieties fall under one and the same name. The following are the names under which nearly all the different varieties have been recognised by the trade. In the tabulated statement below I also give the main distinguishing characters of each. They are further arranged in order of their commercial value.

No.	Variety.	Distinguishing characters.	Cultural Description.
1	<i>Jajai</i> ..	This is <i>Sugdassi</i> (sweet scented) grain long, thin, flutty when broken : with drooping ear-heads, Rice pale yellow.	Takes about 110 days to ripen ; requires good soil and careful cultivation : produced under copious irrigation mostly for local consumption.
2	<i>Prong</i> ..	This is also sweet and scented and possesses the same characters as above but the glume is of deeper colour and possesses an awn ; grain gelatenous.	Same as above ; possesses the additional merit of resisting disease better than (1) but ripens a little later and is a bit difficult to thresh.
3	<i>Sonahri</i> ..	This also sweet-scented though to a less degree with reddish coloured husk. Grain is less flinty, thicker than above two.	Same as above : but ripens earlier than either of the two and the rice contains a less oil percentage.
4	<i>Sadagulah.</i>	Same as (3) but the husk a little lighter colour than above. Grain whitish yellow not translucent like all previously named.	Same as above. Ripens in about 100 days. The yield is generally better than above, but the taste is less delicious and rice is more starchy.
5	<i>Kangni</i> ..	This is not scented. The grain opaque, white straight unlike <i>Jajai</i> which is slightly bent, husk whitish gray with longitudinal grooves thicker and flatter than <i>Sagdassi</i> .	This stands next to <i>Sugdassi</i> class as regards soil cultivation and water requirements, etc. Takes about 90 days to ripen. Can withstand draught better than <i>Sugdassi</i> class.
6	<i>Torh</i> ..	Same as No. 5, but is very starchy brittle, plump and soft. Earhead erect with less percentage of oil and albuminoids.	Same as No. 5. Tillers much more than above and owing to its <i>Kalar</i> (salt) resisting properties always forms the first transition crop in reclamation of salt lands.
7	<i>Malingo</i> ..	Same as above but grain finer and translucent resembling <i>Sugdassi</i> rice without fragrance.	Same as No. 5 but requires more copious irrigation than it. It is not used in 'Josh' process like Nos. 5 and 6.
8	<i>Sighro</i> ..	The grain resembles the following variety except the husk is not red like it. The grain is not so coarse in eating as No. 9.	This is an early variety ripening in about 50 days on which account it is quickly replacing other coarser varieties in Warah taluka.

No.	Variety.	Distinguishing characters.	Cultural Description.
9	<i>Sathri</i> ..	Husk red: grain coarse, white thick : poor in oil and albuminoids but rich in starch.	This is also an early variety. Takes about 2½ months to ripe. Produced under poor cultivation. Eaten by poor folk.
10	<i>Larri</i> ..	The husk is not red but the grain is so. It is a coarse variety, poor folk make it into bread.	Cultivated in low lying fields, ripens later. Produced under less cultivation.
11	<i>Motio</i> ..	Same as above but the husk is also red.	Same as above. Both were imported from lower Sind.

Besides the distinguishing characters given above, the standing crop of these varieties presents to the hand and eye many more unmistakable differences of colour of leaves, coarseness or fineness of straws, the erectness, drooping or spreading nature of the ear-heads and leafiness or otherwise of the stems. The choice of variety depends on the following factors, (1) quality of the inundation, (2) low or high situation of the soil, (3) kind of soil. If the inundation is too late the cultivators will put in short lived varieties like *Sighro* or *Sathri* rather than long lived like *Sugdassi* varieties. In low lying fields where there is likelihood of too much water standing they put in *Larri* and *Motio*, unlike *Torh* and *Kangni*, which should be sown on higher levels where there is no danger of too much water stationing. Poor salt lands should receive a variety like *Torh* rather than the *Sugdassi* or *Malingo* varieties which must be sown on good retentive soils with natural drainage. Arranged in order of long life they stand as follows:— (1) *Sugdassi*, (2) *Torh*, (3) *Kangni*, (4) *Motio*, (5) *Larri*, (6) *Sathri*, (7) *Sighro*. Arranged according to depth of water they can stand they rank, (1) *Larri*, (2) *Motio*, (3) *Kangro*, (4) *Torh*, (5) *Sugdassi*, (6) *Sathri* or *Sighro*. Lastly according to value they have been already classified in the table already given.

RICE PESTS.

Our rice is immune from many diseases, insect or fungus, to which it is subject in other parts of the world. *Ufra* of Eastern Bengal, *Brusoul* of Italy and *Blast* of America

have happily no brother in Sind rice. Even insect pests are few and none of them is a serious danger. The *Cantharid* beetle feeding on the flowers, the *Leptocorisa* bug sucking the ripening grain and grasshoppers eating leaves may be observed here and there but the danger is insignificant. Among animal pests the rat is less annoying than in lower Sind, where it is so very bold as to swim away even to the centre of the field and damage the crop there if it is not satisfied near the *bannas* (embankments). Among the fungus diseases Smut is the only disease observed and it is responsible every year for half an anna damage in a rupee. There is, however, another unknown malady which threatens to be serious. It is sterility or semi-sterility of the heads. This is attributed by the local people to a strong gale of short duration which blows from the west during the following season in the evening or early hours of night. What action it plays on the plant physiology cannot be explained. Outwardly there is evident no other symptom beyond the emptiness of the glumes. It is remarkable, however, that while the wind passes through vast areas of paddy cultivation, yet only a few fields are affected and there too the damage is confined to a few individual plants. This fact leads one to believe that more than mere wind must be the real cause and it is likely that on examination this sterility may be found to be due to some parasite.

Apart from the above unexplained sterility there is one more factor which is acting prejudicially on the quality of rice. It has been observed that *Sugdassi* when continually grown on the same field and in the same environment gradually loses its most distinguishing character of fragrance. Not only that but some sort of redistribution of its fatty, starchy and albuminoid ingredients takes place which consequently make it resemble more the inferior types of rice than the real *Sugdassi*. Moreover, it occasionally happens in rice fields that a particular variety undergoes some physiological degeneration and produces a type called *Gado* (sport)

plant. This may differ from the parent not only in quality of its grain but sometimes the colour of the skin of rice also changes from white to red and *vice versa*. This state of things was reported round about Ratodero and evidently demands careful investigation.

MILLING AND TRADE.

With the expansion of rice cultivation in the district and a limited internal demand for the commodity, the local *bania* capitalist has turned his attention to mobilise the surplus produce for foreign countries. This has necessitated the establishment of paddy mills of which there are about forty distributed throughout the tract and located as near the railway line as convenient. Larkana, Kamber, Ratodero, Badah, Nasirabad are important centres, each of the above containing five factories with an average of about four hullers in each factory. They are mostly driven by steam engines. There are three stages in the process of turning out finished rice through them. In the first, the husk is removed and blown away by blast from fans, in the second, the outter skin or bran is removed. It is at this stage that most of the breakage of the rice grain occurs, and lastly the finer particles are removed by leather bands acting as brushes. In the old method of husking paddy by the pestle and mortar, the breakage of rice is very small and the loss of fat and proteid which results from damage to the rice skin (alearone) in mills is avoided. Such rice still command a higher price.

Josh.--There is also another method of preparing rice for export. It is called *Josh* (boiling). The process is as follows :—First of all dirt is removed from paddy by passing it through sieve. Big earthen pots are filled with paddy and water and kept on ground covered with a six-inch layer of rice husk as fuel. This is then lighted. For the whole night these jars remain there on the fire, next day the water is drained off and the paddy is subjected to a second

heating in shallow iron pans kept on the fire. For an hour each jar is heated and then taken out and spread on roofs for drying. The first boiling is sometimes done in iron tubes instead of earthen jars. In their case, water is first heated to the boiling point and then the fire is removed and clean paddy put in them and allowed to remain there for 8 hours. Then water is drained off and the stuff heated on pans and then dried as described above. By being semi-cooked, the husk easily separates in the mill and there is no breakage of grains. Besides, it is claimed that such rice has better keeping qualities and does not deteriorate when carried on long sea voyages. The rice prepared this way fetches the same price as the usual sort, the extra expenses of boiling, etc., being covered up by the gain in weight during the *josh* process. Thirteen maunds of rice are obtained from a *kharar* (20 maunds) of paddy untreated, but fourteen maunds of rice from boiled paddy. *Josh* prepared rice is entirely for export and there is no local demand for it. Systematic grading of rice is never undertaken in these mills as elsewhere.

By-products from mills.—These consist of the husk, bran and the spent water from *josh*. Husk is used as fuel in *josh* and the surplus is retailed out to cultivators from twelve annas to a rupee per cart-load for *rab* burning or mixing in mud plaster for houses. Bran and small broken grain is called *katti* (meal), is largely used as cattle food and sold from twelve annas to one rupee eight annas per maund according to the percentage of broken grain in it. The water in which *josh* paddy is boiled is thrown away and any one who may have passed by these factories may have noticed the alcoholic smell it emits. It may be worth while investigating its contents with a view to its utilization.

Trade.—The export trade is through Karachi with Persia, some Indian ports and Colombo in Ceylon. For the fact that our rice cannot compete with Burma rice in European market, there is no other explanation but that our quantity

is limited and the milling and grading not up to the requirements of that trade. All the business involved, from the purchase of the paddy crop to the delivery in the countries of export as a finished article, is in the hands of *Bania* merchants. Basing the estimate on acreage in the district 350,000 acres would produce at two-thirds of a *kharar* per acre (deducting one-sixth of a *kharar* for seed and home storage by the cultivator) 175,000 *kharars* of paddy. This quantity will be available for sale annually and at Rs. 50* a *kharar* their value comes to Rs. 87,50,000.

A *kharar* of paddy yields fourteen maunds rice, four maunds *katti* (bran) and two maunds husk. Therefore the above quantity of 175,000 *kharars* converted into mill products mean—

	Rs.
Rice 175,000 × 14 maunds at Rs. 6 a maund in factory	1,47,00,000
<i>Katti</i> 175,000 × 4 maunds at Re. 1 a maund in factory	7,00,000
Husk 175,000 × 2 maunds at Re. 1-6 per maund, cart-load	35,000
Therefore the merchant's gross realiza- tions are	1,54,35,000
Price of crop Rs. 87,50,000	
Milling at Rs. 2-8 a <i>kharar</i> costs	4,37,500
or a total of	91,87,500
We get total value of his annual business	2,46,22,500
And his gross annual profits come to ..	62,47,500
	Rs. a. p.
or after each cultivated acre $\frac{62,47,500}{3,50,000}$..	17 13 7
and we have seen the agriculturists' gross profit	14 11 4

* Rate has since gone up by over 100 per cent.

	Rs.	a.	p.
<i>i.e., hari</i> and zamindars' combined gain per acre is less than that of trademen by	3	2	3

Again on the assumption of same acreage the agriculturists' gross receipts work out to—

Acres.	Rs. a. p.
2,50,000 (2×21-10-8)	
gross receipt on acre	
$3,50,000 \times 2 \times \frac{65}{3} = \frac{4,55,00,000}{3}$	.. Rs. 1,51,66,666

and the Government assessment demands at an average of Rs. 4½ per acre come to Rs. 3,50,000 × ½ Rs. 15,75,000 or 10·4 per cent. of gross produce returns.

If figures of income tax on rice merchant were available it should be interesting how differently agriculture and rice trade fare in matters of Government dues. Supposing there be no evasions and all taxable incomes were included, still the highest percentage charged to incomes of trademan at 6 pies in a rupee is 3·1 per cent.

DUBARI.

Dubari means the second crop sown immediately after harvesting paddy. Crops generally grown as such are wheat, gram, *matar* (*Lattyrus sativus*), coriander, *jambho* (*Eruca sativa lam*), *sariah* (*Brassica campestris*) and *hurbo* (Fenu-greek). The assessment for *dubari* is from four to eight annas per acre in order to induce *haris* and zamindars to keep their soils well tilled and so maintain their fertility. The soils which support *dubari* are generally more retentive of moisture and of good texture.

Wheat.—After the paddy harvest, when land comes in condition for ploughing, the seed is broad-casted at the rate

of one *kassa* (*kassa* = 32 lbs.) per *jireb* and ploughed and cross-ploughed. No other tillage is done. The variety of wheat sown is *thori*. The moisture is ample at the time and the germination is good; but the after-growth of the crop is not vigorous, due to constant cropping of the soil. The plants are stunted, the grain-heads small and the yield very poor, not more than 3 to 5 times the quantity of seed sown. Manure is not generally added to the soil. But such soils as come in condition for ploughing soon after harvest, so that ample time intervenes before sowing of wheat, are manured lightly with well rotten goat manure; ploughed and samed four times and then seeded with a drill like *bosi* wheat. In such soils the yield is about 15 *kassa* a *jireb*. *Dubari* wheat is mostly round about Kamber. Sometimes, in order to keep up the fertility of the soil, a mixture of wheat and *matar* (*Lathyrus*) is sown. This was also seen near Kamber in Deh Chhajra. The cultivator on his own part is not very eager to grow *dubari* wheat as the labour entailed in maintaining it is relatively high considering the amount of wheat usually obtained. But the zamindar compels the *hari* to do it in his own self-interest, as not only does the zamindar get a share of wheat produce, however small, but that at the cost of the *hari* he indirectly gets his lands ploughed up. This tillage is believed to be beneficial to the succeeding paddy crop. *Dubari* wheat is rotated sometimes with gram and *matar*.

Gram.—It is sown in just the same way as *dubari* wheat except that the seed is covered with one ploughing only. It makes excellent fodder for horses and cattle. The tender shoots are nipped off and cooked as vegetable. The growth of the pruned crop is vigorous and the grain yield heavy. The green fodder is sold from Re. 1 to Re. 1-8 per *guntha*. If not cut for fodder the grain yield varies between 400 to 600 lbs. per acre. The returns from gram are more attractive than that of *matar* but the former can grow well only in a sweet soil. Gram cultivation is further liked owing to its restorative qualities on the land. It ripens later than *matar*,

Matar.—This is a hardy plant and grows even in soils containing moderate quantities of *kalar* salts. Wherever the soil is pretty retentive of moisture, this pulse invariably follows paddy. The month of October is the sowing season. At this period, whether the paddy be cut or standing, the seed is sprinkled at the rate of one *kassa* per *jireb*. The soil is generally muddy at the time. After a month and a half it completely covers the pound and the cattle are allowed to graze it off. The grazing continues for a couple of months, and is then stopped as soon as flowers appear in abundance. Early in March the crop is ready for harvest, the average yield being 100 lbs. per *jireb*. If cultivation is kept for green fodder it fetches 12 annas to a rupee per *guntha*. The crop is restorative to a moderate degree. Neither *matar* nor gram is made into hay, but bruised chaff obtained after threshing of gram forms delicious mixture in cattle food. Horses will not eat *matar*.

Hurbo.—Is fenugreek, also called *methi* in Sindhi. This is also a leguminous crop grown for its fodder and seed, the latter being the well-known condiment. The area under this is very small. It is broad-casted either in wet soil or under a plough. The seed rate is about 8 pounds per *jireb*. The seed is dear. The crop gives two good cuttings. The fodder is considered superior even to gram and keeps valuable animals in condition. It is generally sown in nursery bed areas where the remnants of manure stimulate its growth. It is also used as vegetable in the green as well as in the dry state. The value of the yield both of fodder and grain comes to Rs. 50 per *jireb*.

Coriander.—This is sown broad-cast under one ploughing. The seed rate is 6 pounds per *jireb*. The leaves are eaten and cooked in curry and the seed (fruit) forms one of the greatly used condiments in Sind. The area under this is also very small. It will not grow in poor or salt land. The money return from this crop is about Rs. 60 per *jireb*. It is sometimes sown as a mixed crop with gram.

Jambho and *sariah*.—These, as *dubari*, are sown mixed with *matar*. The seed at the rate of 5 to 6 pounds is broadcasted in wet soil with *matar* at the end of October. The crop is ready in March. The yield from the mixed crop is about 300 to 400 lbs. per *jireb*. Both yield oil which is used for burning, and to a small extent in cooking, while it is also mixed with fuller's earth and applied to the body before bathing. It is a very good cool substitute for soap. The oil pressing industry of the tract is dependent on the *jambho* and *sariah* cultivation. There are good many oil mills (country) located in important villages of the tract. Some zamindars are of opinion that apart from Leguminosæ *dubari* crops, which are distinctly restorative, even others are not exhaustive and that whatever plant food they take is more than replenished by the tillage that is given for *dubari*. Another advantage from *dubari* is that the *hari* gets engagement all the year round without leaving his home for outside work during the winter.

ECONOMIC CONDITION OF PEOPLE.

The general condition of the agriculturist is good in comparison with his brethren in the rest of Sind. The wealth is not great but the indebtedness is small. The following remarks will apply to the *haris* and to the proprietors of small holdings who cultivate the land. For convenience sake I shall divide their wealth under two heads, I—Movable, II—Immovable properties. Under the former I shall consider (a) Live-stock, (b) Implements, (c) Household chattels and ornaments, (d) Stored grain or fodder or manure. Under the latter head I put down (a) Land, (b) Dwelling houses and (c) Permanent improvements in the same.

I.—Movable property.

(a) *Live-stock*.—From the amount of tillage and the nature of cultivation of rice in vogue here, the area which can

be safely assigned to a pair of bullocks is high in comparison with other crops with flow or lift irrigation. The transplanting lasts for nearly two months and calculating at the ploughing rate of a *jireb* (half an acre) a day about 25 *jirebs* could be puddled by a pair of cattle in a season. In practice if a cultivator does less area than this, it is due to want of hands. The pair of bullocks does not remain idle, but is lent to the neighbours. Besides, the system of winter ploughing (against puddling) affords further relief to the bullocks at planting time and their ploughing capacity is increased. So that even if we take into consideration the *dubari* plough work and the cartage of produce from threshing yard to the village, an average cultivator will rarely need more than one pair of bullocks. The standard of life among the Sindhi cultivators, however, compel a man to keep milch animals and usually he will have a cow or a buffalo and one or two young stock. Thus we see that as regards live-stock a cultivator's assets are meagre, and considering the condition in which they are kept, a sum of Rs. 70 would be a fair price for them all (a bullock, a cow and a couple of young stock).*

(b) *Implements*.—A light plough, sickle, a *kodol* (spade), a forked rake are all that a cultivator has in the way of tools and implements in the rice tract. Of late years it has been usual to pay for these in cash. They are light and of so very indifferent shape and make that they hardly last for over a year. The plough is usually a very ineffective implement and it is to a great extent responsible for the rank growth of weeds in almost all the fields, especially in the early period of rice growth. Rs. 4-12 will buy all these implements.

(c) *Household chattels and ornaments*.—Of late years there has been distinct fondness for these. Where two decades ago, earthen pots which the local potters produced for a nominal price only, now we see copper kettles and brass pots replacing the former. Formerly the farmer never thought his holiday suit would be soiled if he packed it away

*All these figures refer to the prices of 1917.

among the thatch of his hut, but now he has wooden boxes made for it. To be brief he has not lagged behind times when the standard of living and comfort has been raised all round. Whatever little money he can put by he utilizes it towards better living in domain of dress or ornaments. The better price for produce, ample employment and the contact with towns induced by cheap and improved communications have largely tended to bring about this change, with the consequence that the agriculturist lays out comparatively more money in this form of unproductive investment than in financing his profession liberally. Making due allowances for depreciation consequent on the wear and tear of household effect and female jewellery, the average *hari* may well claim a sum of Rs. 175 as the net value of these; by mortgaging these he can raise a loan on short accommodation. The petty proprietors' wealth in this form is comparatively great and the landlords' still greater.

(d) *Stored grain, fodder or manure.*—About 75 per cent. of rice cultivators possess a reserve of these, the quantity of which depends upon the *hari's* family, the number of live-stock and the area to be cultivated. The average stock of grain and straw for a force of five members of the household, five head of cattle and 12 acres cultivation would come to a *kharar* and a half of grain for seed and maintenance and about 20 rupees worth of paddy straw. The manure from average number of cattle owned by *hari* yields about 15 cart-loads apart from what is wasted in the jungle during grazing. The cart-load would fetch 10 to 12 annas and weigh about 6 maunds (480 to 500 maunds); the whole quantity is used in *rab* burning and employed as fuel for cooking. Whatever manure is available from big zamindars' stables is also free to the *hari*. The money value therefore of the stored grain, fodder and manure may come to Rs. 105. The store reserved of grain of a big zamindar may be anything up to 100 *kharars* of paddy for use of their establishment and on loan to his less provident *haris*.

II.—Immovable property.

(a) *Land*.—The *hari* is a tenant-at-will and possesses no permanent interest in land and therefore does little to improve it. The zamindar is the owner but he is equally less zealous in matter of effecting improvements to the property. Only one in a score of big zamindars may be paying adequate attention. As long as a zamindar is owner of big areas, his time is taken up in managing merely the broad outlines of work, *viz.*, importation of tenants and money dealings with them, recovery of produce share, etc., and arrangements of water supply. The petty proprietor has been observed to evince the greatest zeal in the improvement of his property. He has built up protective bunds (embankments), levelled his lands of all unevenness and reclaimed *kalar* patches. If at some places the level of the plots is disturbed by the deposition of silt from water courses, he carefully scrapes it into neat heaps which he removes in slack times. For these improvements he generally engages paid labour and it would be difficult to work out even approximately the average form so expended by each landowner. The extent of the wealth of the zamindars in land and its improvement can only be gauged by land values (*vide infra*).

(b) *Dwelling houses*.—About seventy per cent. of the population may be possessing a house in a village adjoining the fields in which they work. The rest generally dwell in *kachha* huts temporarily built of materials gathered from the jungle or borrowed free from the zamindar within the latter's proprietary limits. The houses beyond providing scanty shelter to the inmates of the household serve no other purpose of comfort. Of animals only very valuable ones get protection from the extremes of temperature. The houses are not worth much in case of *haris* but those of small landowners in easy circumstances are pretty good and their value may be anything up to Rs. 600 while owners of big estates live up to their incomes in sometimes very large and comfortable buildings furnished to taste.

INDEBTEDNESS.

The indebtedness of the agriculturist here is due to the following causes: (1) the *hari* may have come to this tract penniless and in order to tide once a season may have recourse to debt. In case of landowners, big or small, the debt may be ancestral, (2) the agriculturist as a rule do not provide for expenses arising out of any untoward events, for instance failure of crop, and subsequent inability to pay *takavi* or assessment demands, or protracted illness, or expenses of litigation arising out of sudden disputes, (3) social customs, or customs and temptations to live beyond one's means.

The *bania* is the only money-lender here as in all Sind. His rates of interest vary between 12 to 100 per cent. Since the operations of the Deccan Relief Act were extended to Sind, there has been contraction of debts to the *hari* or the zamindar unless he pledges some of his household goods or ornaments or effects a sale of such portion of his land as to cover the advance. *Hari* can never get money on personal security but the credit of respectable zamindars is good and they get large sums advanced to them at 12 per cent. Land mortgages are almost insignificant of late years, but the number of holdings or portions of holdings passing into money-lenders' possession is still increasing. The sales are, however, limited to one or two acres as a rule, in each case. The people being mostly ignorant and illiterate, once they get into debt, they can hardly ever get out of it. Fortunately rice cultivation pays well and if new debts are incurred it is only on emergency occasions such as I have already mentioned. Old debts have been satisfied by sales or their extent has been reduced by speedy payments. Nowadays we find the *bania* pays more attention to short term loans which represent the major portion of his present business. On the whole he is not so ruthless money-lender of past and the people, thanks to good irrigation systems, are in little want. Owners of big estates are improving in wealth and appear to be affluent in many

cases. Small proprietors generally are in a position now to meet their normal crop requirements from their own purse and are not so much dependent on the money-lender as formerly.

LAND TENURES.

Share-cropping.—All land belongs to the zamindar who gets it cultivated by a *hari* (tenant-at-will) on what is known as *batai* (division of produce). The zamindar bears the charges of land revenue and arranges about the necessary water supply but all the cultivation is done by the *haris* who employ their own labour and cattle to bring up a crop. The shares usually are :—

Produce.	Zamindar's.	Hari's.
Paddy grain ..	$\frac{1}{2}$	$\frac{1}{2}$
Paddy straw ..	$\frac{1}{3}$	$\frac{2}{3}$
<i>Dubari</i> grains ..	$\frac{1}{2}$	$\frac{1}{2}$
<i>Dubari</i> bye-product ..	$\frac{1}{3}$	$\frac{2}{3}$

This is subject to a deduction from the *hari's* share of a *lapo* (royalty) of half a *kassa* of paddy grain per *jireb* of cultivation. The zamindar incurs the charges necessary for the clearance of the water-courses or *karias* and advances, if required, money free of interest to the *hari* at the most equal to a quarter of the estimated value of the crop undertaken by the *hari*. This is recovered at the time of *batai*.

In case the land to be cultivated is bad *kalar* or infested with jungle growth or demands more than the usual amount of labour to bring it into cultivation, the above conditions are relaxed in favour of the *hari* who gets three-fifths or two-thirds of the grain produce instead of a half. Of late there have sprung up many small proprietors who own lands but themselves cultivate them.

Cash Renting.—Is not much in vogue in the rice tract but if zamindar is less careful or if it happens to be a lady who cannot undertake outside management, the land is rented out to the actual cultivators on a rental varying from Rs. 6 to Rs. 12 per *jireb*. The usual zamindar's expenses still fall upon him, that is to say, the Government assessment and the clearances of *karias*.

Subletting.—Under the same reasons as above, the land is sometimes sublet to capitalists for a fixed number of years and for a fixed sum involving whole estates. Cases of such subletting are fewer than of renting for cash, yet all the estates under the court of wards or the Incumbered Estates Act fall under this category. In this system the lessee plays the roll of zamindar in the cultivation of the property. The annual payment to the estate owner depends upon the value of his estate as a whole.

Share Renting.—Sometimes the zamindar rents out his half share on annual produce to contractors who manage the business on his behalf paying assessment, etc., and recovering shares from the *haris*. The contractor in these cases is always the *bania* who must have some previous money demands upon the zamindar. In fact this is an ingenious way hit upon by the shrewd *bania*, who thereby without infringing the Deccan Relief Act or the Incumbered Estates Act has still drawn the zamindar into his clutches and has secured himself against delinquent payments. Cases of share renting are not few and almost all the indolent zamindars have now recourse to it. The average rental generally exceeds the annual assessment by one or two rupees per acre.

It would be interesting to work out by how much loss the zamindar is hit annually by each of the various systems of land tenure and if figures of actual profits could be had of *bania* contractors, most reliable figures of incidence of assessment could be worked out, because the *bania* lessee's management is economical and business-like. From the experience

of these various systems, it has been admitted that the share cropping system is the best alike for the proprietor and the tenant wherein both feel themselves equally interested and if the 'Mourusi' (hereditary) *hari* system as it exists in parts of Hyderabad Collectorate, obtained here, in Larkana, this system would be productive of the maximum results. In other systems the interest of the parties is temporary or confined to a portion of a season's produce. No permanent improvements are effected in such estates and the consequent neglect badly tells upon the fertility of the soil.

The relations between *hari* and zamindar are generally conciliatory but instances of bad dealing on the part of one and aggression on the part of the other do happen especially in tenancy systems other than share cropping.

LAND VALUES—RENTS AND ASSESSMENT.

The value of rice land as of all other cultural lands depends upon the facilities of irrigation, the nature of soil, and proximity to a village, market or a railway station. Rice lands as a rule are favourably situated for irrigation. This consideration and the ease with which the natural defects in a soil can be cured by irrigation, make the value of rice land second to none but mango or other fruit plantations. I have myself known two sales contracted at Rs. 2,000 per acre for rice land. One of them is a recent transaction in Hyder Chandio's village (Mirokhan). Apart from these fancy prices, Rs. 500 to Rs. 800 per acre of first class rice land and *dubari* land are common and a price of Rs. 300 to Rs. 400 is average, Rs. 200 to Rs. 300 per acre is below average price. In registry records genuine sale prices are rarely given and are much deprecated and the reason why the parties contracting the transaction do so is to conceal their wealth from public inquisition. Good rice land is seldom put out to sale. Without exception the seller is a Mahommedan pressed by pecuniary straits and the thoughtful *bania*, who feels land is the best investment, is ever ready to buy.

Rents.—These are detailed under land tenures (*vide supra*). It is necessary here simply to work out the rent money paid by the *hari* in the shape of half the produce to the zamindar. Under the head of 'profit and loss' above, it will be seen that the average produce is twenty *kassas* of grain worth Rs. 16-10-8 at Rs. 50 a *kharar*. The *hari* tenders half this amount, *viz.*, Rs. 8-6-4 plus $\frac{1}{3}$ of the paddy straw, *i.e.*, Rs. $\frac{5}{3}$. Adding value of grain and straw we get Rs. 8-5-4 plus Rs. 1-10-8 = Rs. 10, in other words this is the amount the *hari* hands over to the zamindar as rent. Thus the zamindar's net profit is :—

	Rs.	a.	p.
Total receipts per <i>jireb</i>	10	0	0
<i>Deduct</i> assessments Rs. 2-4-0	2	8	0
<i>Karia</i> clearance charges 0-4-0	0	4	0
Net profit	7	8	0

The *hari's* net profit is —

His total receipts per *jireb*—

Grain Rs. 8-5-4	11	10	8
Straw „ 3-5-4	0	5	8

Deduct cost of cultivation—

Total cultivating expenses	11	5	0
Rs. 13-13-0.	0	13	0
<i>Deduct</i> those paid by zamindar	0	8	0
Rs. 2-8-0.	0	5	8

∴ *Hari's* net profit per *jireb*.. 0 5 8 per *jireb*.

Assessment.—The Government land tax varies according to the class of soil and the crop. It is paid for each season separately in one or two instalments at the end of that season. For rice land the assessment varies between Rs. 3-12-0 to

Rs. 5-6-0 per acre according to the class the particular land may have been put in the survey settlement. The assessment is liable to remission in case of failure of crops. Besides the Government advances *takavi* advances to the zamindar at a very moderate rate of interest ($6\frac{1}{4}$ per cent.) for agricultural improvements. These are also recoverable in instalments. In the particular case cited above the ratio of gross produce to assessment is as 260 : 27 and the ratio of zamindar's profit to assessment is as 10 : 3.

LABOUR AND CATTLE.

The unit of labour engaged in unit production of rice is much less in comparison with other crops. We have seen above that a *hari* with a pair of cattle can easily cultivate 25 *jirebs*, and when pressed by transplanting or harvest operations he has ready at hand outside labour to relieve him. The labour is raised in many ways :—

Hired labour.—Much of this is available during the slack months of December to April and the rate of wages varies according to localities normally between 6 and 7 annas a day. During this time the zamindar generally gets the *karia* (water-course) clearances done or any other permanent improvements in land. During the *kharif* season this labour returns to rice cultivation from which it cannot be spared unless wage of twelve annas to a rupee is paid per day and the demand is not great.

Job workers.—Two operations in rice cultivation require much labour and the local supply cannot cope with them. For these special communities of workers spread themselves at the time of these operations throughout the rice tract and perform the operations on contract system. The *Machhi* and *Sheikh* castes generally do the transplanting at rates bearing from Rs. 1-8-0 to Rs. 2 per *jireb*. They work during the cool hours of the forenoon. For the harvest, hordes of *Brohis* come down from the hills, reap the crop and receive

their wage in kind, *viz.*, two to three *kassas* of grain per *jireb* together with an ample paddy straw allowance for their cattle which accompany them.

Paid servants.—These are not common but are engaged when the *hari* or petty proprietor has little family to support him in his work. The monthly pay ranges from Rs. 6 to Rs. 10 plus two full meals a day during the working season.

Abat or Wangar System.—This is well-known practice of raising labour in return for a meal only. When a zamindar wants to get a portion of his own land cultivated by himself for his own exclusive use or he is limited by pecuniary circumstances to defray the cost of clearance of the *karias* or of any other emergent work, he invites the neighbouring *haris* with whom he may be on good terms to do the work. After a half day or a day's work he feeds them with a full meal.

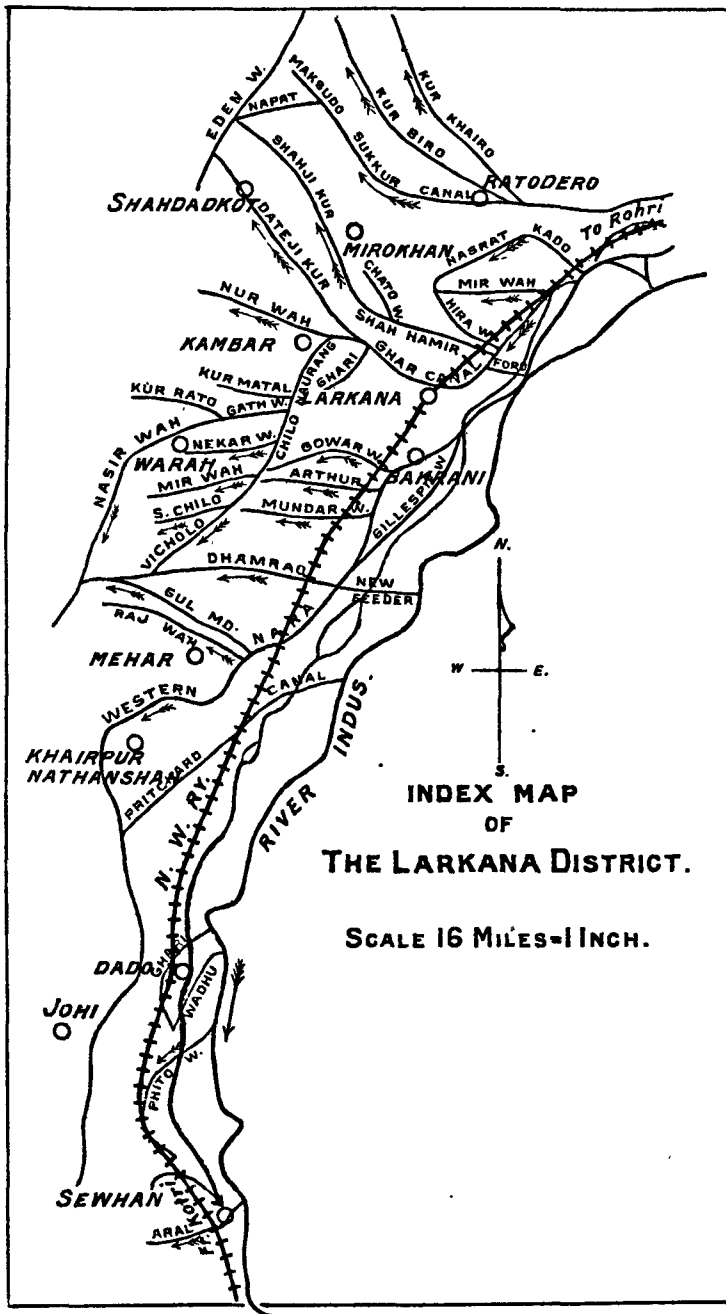
Labour Exchange.—Sometimes the *hari* is pressed by work and has no means to finish by any of the above ways, he requests his neighbour who may be available at the time to help him. In return when the other is in need of help the first readily supplies it. A good many people in the tract help each other in this way and their idle time is thus utilised to each other's advantage.

CATTLE.

The plough cattle are comparatively fewer in the rice tract than in any other. The other stock too is not large in number as there are few unoccupied areas wherein to give them grazing or exercise. Buffaloes seem to do better than cows in the tract. The local cattle is not as poor a specimen as those of Upper Sind generally. Besides paddy straw, of which there is an abundance, concentrated foods are allowed to them during the working time. The chief of these concentrated foods are *katti* (rice bran) and *jambho* oil cake. *Dubari*, *matar* and gram fodder that is grown is a great boon for the cattle of this tract. The milk and ghee (clarified butter) products from cows and buffaloes are all consumed

locally and at the most reach the nearest market town. They are, in fact, not produced in commercial quantities. The plough cattle are so very few that he-buffaloes where available are used for puddlings and cows help to a great extent in threshing. For the haulage of produce from the threshing yard to the market, the plough cattle again come to the assistance of the *hari* but from local market to centres of commerce like Kamber, Nasirabad, Larkana, Ratodero, etc., or to railway stations the transport of produce is done by camels, donkeys, pack-bullocks and bullock carts. The cart-bullocks are mostly well fed and much cared for. Their prices will be about Rs. 200 a pair. Throughout the year, the fodder supply is ample in the tract. Paddy straw, wheat chaff, green *matar* or gram, or *hurbo* is available apart from so many edible grasses growing as weeds. There also exists the practice of feeding valuable animals on green paddy cut when approaching the flowering time. Moreover weeds from paddy fields especially *Savri* (*Panicum Isachne*, Roth.), *Dabhuri* (*Cyperus Rotundus*, Linn.), and others growing along embankments and water channels like *Chhabar* (*Cynodon Dactylon*, Pers.) and *Kabho* (*Saccharum Spontaneum*) give good green grass grazing to the cattle. Where paddy crop has luxuriant leafy growth, the cattle are allowed in the cultivation to graze out the tops. There is not much stall feeding except for cart-bullocks and milch cows and buffaloes.

Diseases.—Epidemic diseases do occasionally appear but do not make wholesale victims. Cases of 'Aphri' (Tympassitis), 'Karo Vao' (Anthrax), 'Muhk̄hur' (Foot and Mouth disease) are only noticeable in the tract at times here and there.



Department of Agriculture, Burma

BULLETIN No. 17
1921

INSTRUCTIONS ON
BEE-KEEPING

BY

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ASSISTANT ENTOMOLOGIST, BURMA



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FOREWORD

THE instructions given in this leaflet are meant to help the beginner to start bee-keeping with the locally available Indian Bees. Those who want fuller and detailed information regarding bees are recommended to read Pusa Bulletin No. 46 on Bee-keeping, available from the Director of the Agricultural Research Institute, Pusa, price 14 annas. The Assistant Entomologist, Burma, Mandalay, will be glad to render any help he can to all enquirers. The illustrations in this leaflet are copied or adapted from Pusa Bulletin No. 46.

INSTRUCTIONS ON BEE-KEEPING.

The Bee-Colony.

Honey-bees live in large colonies. The place where the colonies live is known as their hive and they build combs there. The combs, as we all know, hang downwards and have a double series of well-like cells in horizontal position with their mouths opening in opposite directions. The cells of the comb serve as store-houses for honey as well as cradles for the young, usually called the "brood." If the bees are made to move away from the combs or the combs cut off, we usually find the cells in the upper part filled with honey and those in the lower part containing the brood. The brood or early stages of the bee are exactly like those of ordinary wasps. The mother bee lays small tubular white eggs, one in each cell. White, soft-bodied, wormlike grubs hatch from these eggs, are fed by the bees and grow and then go into a sleeping stage. The bees, as we see them, emerge from this sleeping stage and take their place by the side of the older bees in the colony.

The bees in the colony sit clustering over and entirely covering the combs, thus keeping the brood warm. Some of them are found constantly going out of and coming into the hive throughout the day. They do not fly at night and in foggy weather or when it rains. The members constituting the colony are the mother bee known as the "queen," a large number of working bees called "workers" and some male bees called "drones." There is a single queen in the colony and her only function is to lay eggs. Bees develop from these eggs in the way described above. The queen lives for about three years. The workers perform all work necessary for the colony, such as building combs, nursing the young, collecting food, keeping the hive clean and guarding it against enemies. Therefore the larger the number of workers present the better the condition of the colony in all respects. But they do not live for more than about three to six months. Therefore in order to replace those which die it is necessary to rear some young throughout the year, and this is what actually takes place. When food is available in abundance, rearing of the young is carried out on a very large scale and necessarily the number of bees in the colony increases rapidly. Food is available in large quantities, once in Autumn (about September—November) and again in Spring (about February to April), and these seasons are known as seasons of honey-flow. In hill-stations the Autumn honey-flow is more important than the Spring one, while in the plains the Spring honey-flow is more important than the Autumn one. When in these seasons the bees in a colony have increased sufficiently so as to feel a little overcrowded, they usually divide themselves to form new colonies. About half of them issue out of the hive for this purpose with the reigning queen and go and establish a colony elsewhere. This is known as swarming. Provision is made for the birth of a new queen in the old colony which thus goes on as before. The services of the drone are required to fertilize the new queen. As the drones help in no work of the colony and in fact live on the store of honey gathered by the workers, being incapable of

procuring their own food, their presence in the colony is tolerated only in the seasons of honey-flow. No drone is generally found at other times of the year.

Products of Honey Bees.

People rob the bees of their combs and squeeze out the honey stored in these combs. Where do the bees get this honey from? Most plants, such as grasses, weeds and trees secrete in minute quantities a sugary liquid called nectar in their flowers. Honey Bees collect these minute drops from the flowers principally for use as food for themselves and store the surplus in their combs in the form of honey for future use. This is why we find many bees always flying between their hive and the fields. They go up to a distance of about two miles all round their hive to collect nectar. Surplus is available only in the honey-flow season to be stored in the combs and in large quantities only in the time of the important honey-flow of the locality.

The combs from which the honey has been squeezed out are melted and yield the well known bees-wax. From where do the bees get this wax to build their combs with? They secrete it from their body through special organs called wax plates situated on the under surface of their body and build the comb by moulding this wax with their mouths.

Besides yielding honey and bees-wax, the bees perform another very useful function to benefit growers of various crops and fruits. While visiting the flowers for nectar they also collect pollen from them for use as food for their young ones. This pollen is the fertilizing element of flowers. As they go from flower to flower for nectar they mechanically distribute the fertilizing element among the flowers and thus help in the setting of fruits. There are many kinds of plants which do not produce any fruits unless their flowers are visited by bees.

Keeping Honey Bees.

It is possible to keep bees and get honey from them without killing or causing them inconvenience and without breaking or squeezing their combs. For this purpose they are made to build combs and live in artificial hives which can be kept in the garden or in the verandah of the house. The hives can be opened whenever one wants to see what the bees are doing. When honey is stored it can be taken out of the combs in the purest condition and the combs given back to the bees to fill again.

Which Bee to keep.

In this country four kinds of honey bees occur :—

- (1) The first is the Rock Bee, colonies of which build huge single combs, sometimes about 4 or 5 feet in diameter, in open places such as faces of rocks, branches of large trees in forests or walls of buildings.
- (2) The second is the Indian Bee, colonies of which always build combs in closed covered situations such as cavities in the ground, walls or tree-trunks and unused boxes or tins.

(3) The third is the Little Bee, colonies of which build small single combs in open situation, in bushes, under eaves of huts and cornices of buildings, behind doors and windows, in fuel stacks and in various similar places.

(4) The fourth is the Dammar Bee. It is not a true Honey Bee but is included here because its colonies gather small quantities of honey which is collected by people for medicinal purposes. These colonies live in hollow walls or tree trunks and build their combs not with wax but with a resinous substance known as "*Pwe-nyet*." The combs usually extend beyond the opening of the hollow in the form of a funnel.

Out of the above four kinds only the second, *i.e.* the Indian Bee, is capable of being kept in artificial hives. The Dammar Bee which, too, lives in closed situations like the Indian Bee is much smaller than house-flies, while the Indian Bee is much bigger than house-flies and has yellow bands on the body. Also the Indian Bee always builds several combs side by side. Therefore no mistake can be made about the kind of Honey Bee one should look for in order to keep in artificial hives.

Frames for Combs.

For keeping in artificial hives the bees are made to build combs in movable wooden bar frames shown in figure 1 in which measurements are given. These frames are made with strips of deal wood $\frac{7}{8}$ inch wide; the upper bar is $\frac{3}{8}$ -inch thick and the lower and the side bars $\frac{1}{2}$ inch thick.

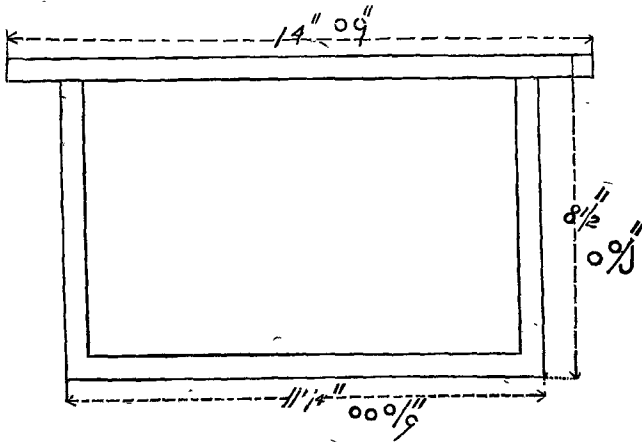


Figure 1.—Bar-frame.

One dozen frames are ordinarily sufficient for each hive. The frames have to be kept parallel and at regular distances in the hive. This is done by putting two nails one near each end on one side of the upper bar of the frame so that the nails project $\frac{1}{4}$ to $\frac{3}{8}$ inch out of the bar. Tin metal ends are used for this purpose but nails will ordinarily do.

(4)

Comb-fixers.

Each frame should have two comb-fixers which may be made with copper or iron wire bent with pliers or of thin strips of wood into

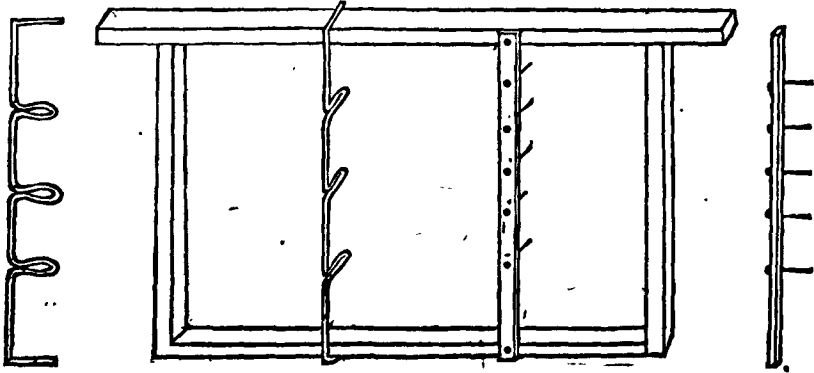


Figure 2.—Comb-fixers.

which nails are fixed. How the comb-fixers are attached to the frames is shown in the figure.

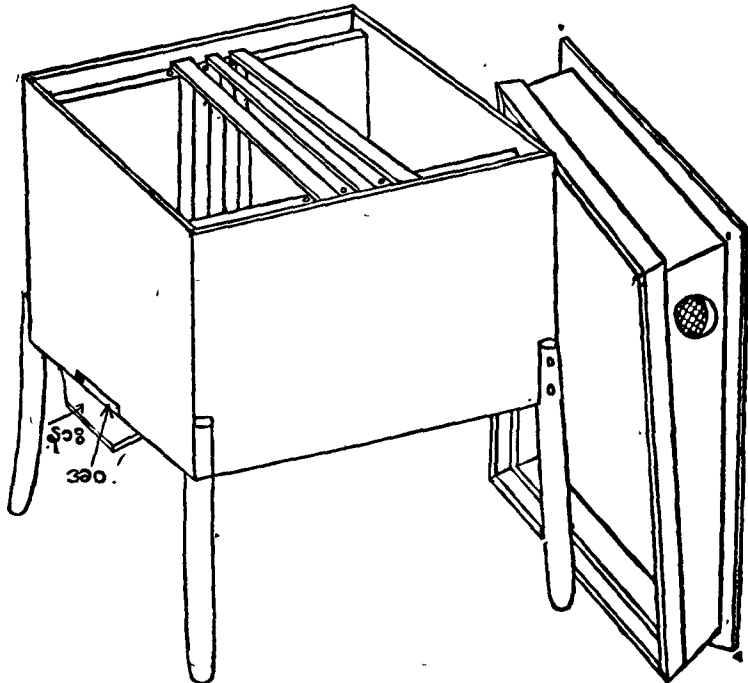


Figure 3.—Kerosen-box Hive, open, with 3 frames in place. 451—Landing-place.
330—Entrance.

The Hive.

A cheap workable hive can be made from an ordinary kerosene packing case by adding a wall inside along each of the longer sides and four legs as shown in figure 3. The frames of combs rest on these inner walls which are $8\frac{1}{2}$ inches high from the floor of the hive and $12\frac{1}{2}$ inches apart. A hole is made at one end near the floor to serve as entrance and a strip of wood added to serve as alighting board for the bees. The cover is made sloping and if not rain-proof protected with a sheet of old kerosene tin to prevent rain water. It has two holes protected with wire-gauze for ventilation. Such a hive complete with cover is shown in figure 4.

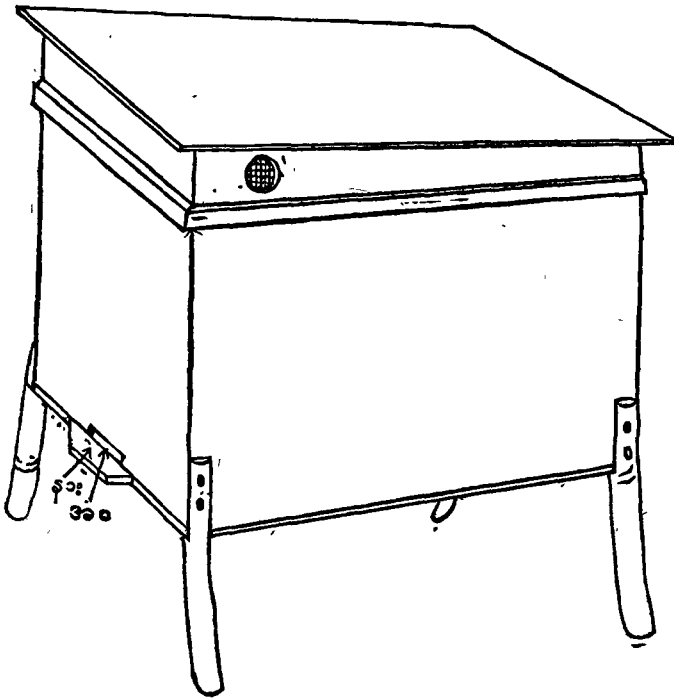


Figure 4.—Kerosene-box Hive, closed.

(6)

Figure 5 shows a good hive made with deal wood $\frac{1}{2}$ inch thick.

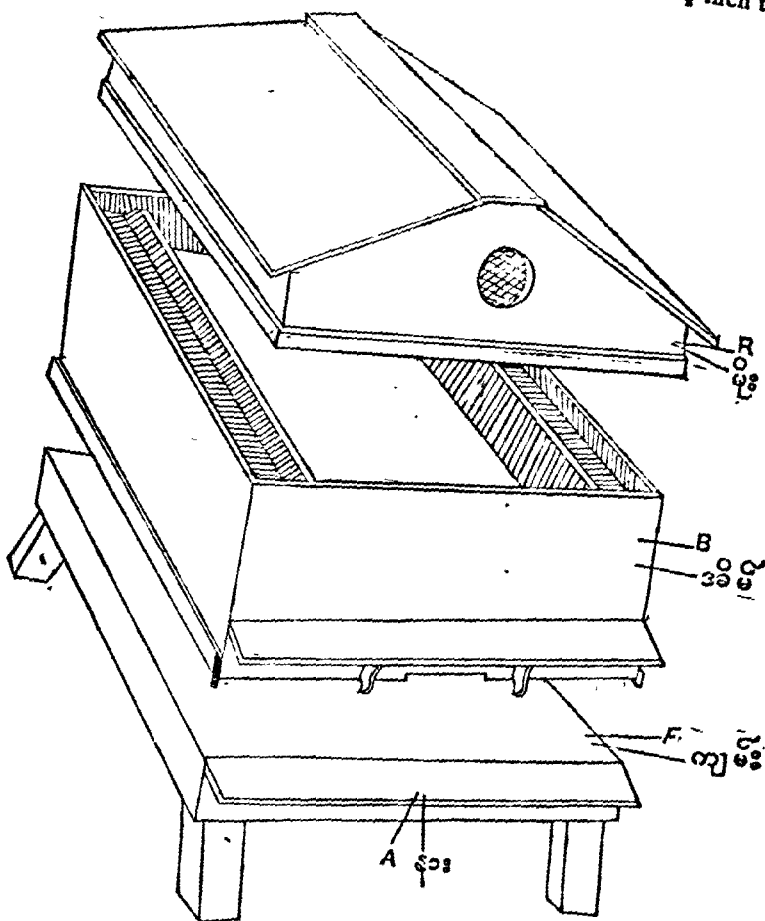


Figure 5.—Hive Roof (R). Hive Chamber (B) and Floor-board (F) shown separately. They fit into one another.

(7)

The floor-board, hive chamber and roof are shown separately.

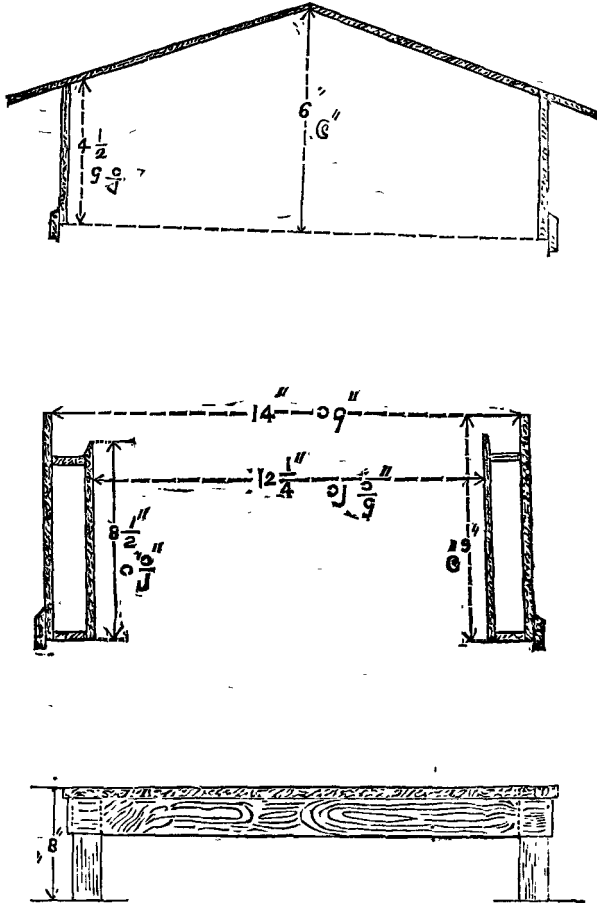


Figure 6.—Measurements of hive shown in Figure 5 in cross section from side to side.

The measurements are shown in figure 6 in cross section. The inside measurement of the hive chamber from front to back should be 17 inches. The hive is painted white on the outside.

Division-board or Screen.

When the combs occupied by the bees living in the hive do not fill the hive, they are pushed towards the entrance and the wooden screen shown in figure 7 is placed behind them thus—affording the

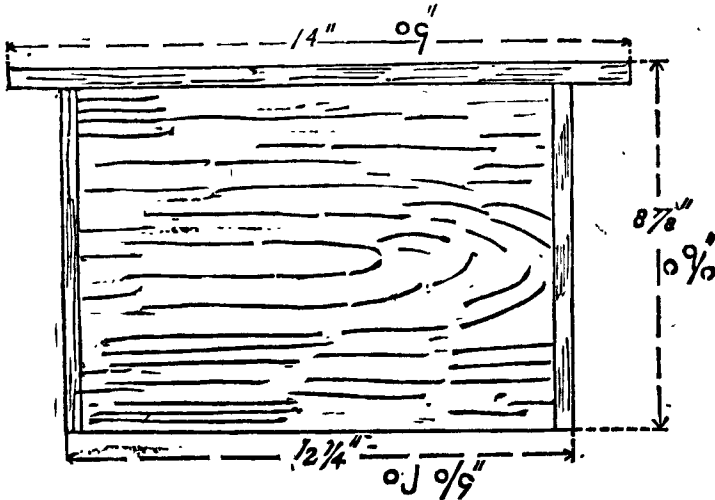


Figure 7.—Division-board or screen.

bees a completely enclosed chamber. This screen is prepared with an ordinary wooden board about half an inch thick. Each hive should have one such screen.

Quilts.

The combs in the hive are covered with a piece of gunny cloth or old carpet; blanket or oil-cloth, cut to the size of the inside measurement of the hive. This is called a quilt. In winter several folds of quilts may be necessary to keep the bees warm. In the hot weather only one sheet may be sufficient.

The Bee-keeper's Knife.

The blade is about six inches long and both the edges as well as the tip are sharpened and may be used for cutting. One such knife is sufficient and it can be made by local blacksmiths.

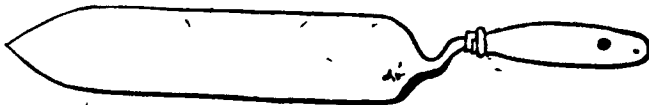


Figure 8.—Bee-keeper's Knife.

It is like the mason's trowel and is shown in figure 8.

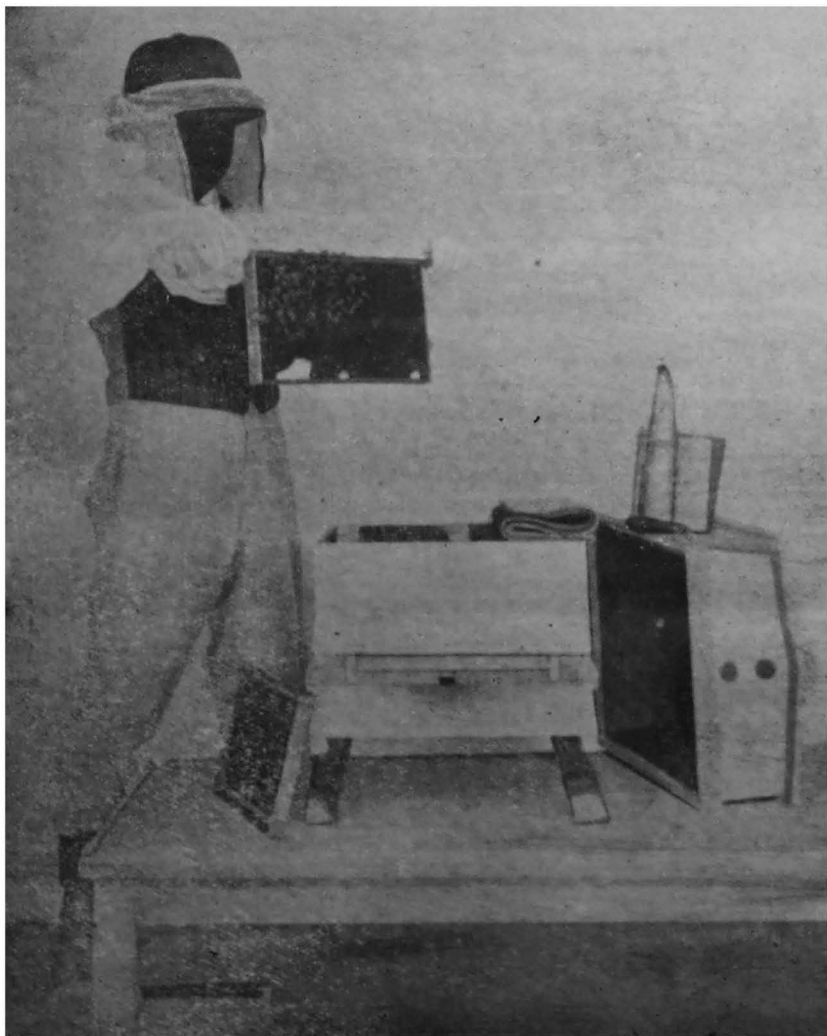


Figure 9.—Examining a hive.



Figure 10.—Examining a hive.

Gloves and Veil.—It is better to be provided against the sting. When angry the bees fly at once at the face. Therefore a veil can be used as shown in figures 9 and 10. The veil is made by sewing a piece of mosquito netting and the portion in front of the eyes should be dyed black for distinct vision. Similarly the hands can be protected by gloves (Figure 9).

Subduing Bees.—Bees have a dislike for or are rather frightened at smoke or any strong odour, such as that of carbolic acid. When frightened they fill themselves with honey and when so filled show hardly any inclination to sting and remain quiet. Smoke of burning rags or wood or mild tobacco may be blown on them. For smoking bees a special smoker (Figure 11) is manufactured and sold.

How to procure Bees and make a start.

Colonies of the Indian Bee can be procured in the following three different ways :—

(1) By means of decoy hives. Melted bees-wax is applied to the underside of the upper bars of the frames and these frames are arranged in the hive near the entrance and closed up with division board and quilt and cover. Thus arranged the hive is left in a shaded place. Frequently colonies come and occupy these hives. The decoy hives should be placed out in September and March—April in hill-stations and about December in the plains.

(2) By capturing swarms and hiving them. In the swarming seasons stray swarms are frequently found to come and settle on branches of trees, walls and other open places. If the place be accessible, the swarm can be captured in the following manner :—

Take a wooden or cardboard box about 9 inches by 9 inches and 6 inches deep with one side open. Hold the box open side down just over the cluster of bees or rather touching the cluster and apply smoke gently to the bees from below. The bees will slowly crawl into the box which can then be taken and placed inside the hive arranged as in (1), the screen board and some frames being removed for the purpose. The box with the bees should be placed with its open end turned towards the frames and touching the nearest one and if the bottom and sides of the box are drummed with a stick the bees will gradually leave it and occupy the frames. If the box into which the swarm has been driven is too big to be accommodated in the hive, the quilt may be turned over and some of the frames moved towards the back. The entire swarm is jerked down the gap thus produced and the frames drawn forward and the quilt turned down quickly. When a swarm has settled on a branch it can be jerked down at once into the hive in this manner by giving a hard and sharp blow on the branch. Before hiving the swarms in this manner the bees may be treated to sugar syrup which is simply sprinkled on the cluster and the bees will be found to lick it up from each other's body.

Newly hived swarms are better fed with sugar syrup for two or three days. The syrup is placed in a saucer and a few pieces of straw placed in it to serve as floats and the saucer kept on the quilt under the cover. Either a hole is cut in the quilt or a corner of the quilt turned over to enable the bees to have access to the syrup.

(3) When a colony has already settled and built combs in a place, the combs are cut out along the line of attachment and fixed into frames which should be fitted with comb fixers. Each comb is fixed on the comb-fixers with its upper edge touching the under surface of the upper bar of the frame. If the upper edge of the comb is not straight a portion can be cut off to make it straight. The bees are smoked plentifully and as they recede the combs are cut one after another, fitted into frames and hung in the hive. Most of the bees will now remain clustering at one place from which they can either be driven into a box as in (2) or scooped up in a bowl and poured over the combs already placed in the hive. They will move down and occupy the combs. Transferring a settled colony in this manner is better done after sunset when the bees do not fly. It can also be done during the middle of the day, but many bees fly and hover round the operator. Also transferring is easily done when the colony is in a box or in a like situation. When in a cavity in tree-trunk or wall or underground a wide opening has to be made to allow of the cutting of the combs with hand. If it be necessary to move the colony to a distance it should be done at night.

Colonies procured according to the methods (1) and (2) sometimes build cross combs and join several frames together. In such cases the combs should be cut and fixed into frames with comb-fixers.

General.

When the bees have settled in the hives it is not necessary to open the hives every day to see what they are doing. On all ordinary days they will work, flying out of the hive and bringing in honey and pollen. For examining the bees, the hive is better opened in the middle of the day when it is warm. First of all remove the roof and blow some smoke under the quilt and wait for a few minutes. Then turn over the quilt and lift one frame at a time slowly by holding the two ends with the thumb and index fingers of the hand.

Although not plentifully as in the honey-flow seasons, the bees usually collect sufficient food throughout the year to keep them going. They need not be supplied with food as long as there is any honey left in their combs. In the rainy season they get little forage outside and if it rains continuously for several days they may require food and may be given sugar syrup in saucers in the manner described above.

When enough surplus honey has been stored in the combs it can be taken out by turning the combs in a proper honey-extractor.

If left opened and exposed, honey absorbs moisture from air and ferments and may become sour. It should be kept in well corked bottles or china or tin vessels and stored in a dry place.

PLATE IV.



Department of Agriculture, Bombay.

BULLETIN No. 105 OF 1920.

THE GROUNDNUT BUG AND ITS
CONTROL

BY

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THE GROUNDNUT BUG AND ITS CONTROL.

The insect which we have termed the Groundnut Bug (*Aphanus sordidus*) is an extremely common one in India, and has usually been considered to have little, if any, agricultural importance. It is true that twenty years ago it was stated by De Niceville to have been found to damage the *til* or sesamum crop, but the bug is so common and usually is so harmless that the observation has been doubted by the most competent authorities. The latest records do indeed note it as a minor pest of stored *til* (sesamum) seed, groundnut, and one or two other products in South India, and as attacking the plants of these crops in the field also. But everywhere its importance has been considered to be small, and it has been looked upon as being a pest which can be checked without difficulty.

On the introduction of groundnut cultivation on a large scale in the Konkan, it was therefore with very great surprise that the bug under discussion suddenly appeared as a very serious menace to the future of the crop in that part of the Bombay Presidency, and between 1914 and 1916 the damage which it did was so serious and the difficulties in the way of checking it seemed so great that it became questionable whether it would be possible to establish the crop in an area otherwise extremely suitable to it.

It first attracted our attention during the year 1914 when it was reported to have injured the groundnuts grown on the Bandhan farm (Kolaba district, Bombay Presidency) to the extent that nobody would buy them when sent to market. The groundnuts were not only shrivelled in appearance, but they presented a bitter taste and when broken open showed yellow patches in the flesh. On the farm in question, the whole crop of groundnuts had simply to be thrown away owing to the rancid and bitter taste of the nuts. As other growers had the same experience, it became important to investigate the whole life history of the bug, to ascertain in what manner it could best be dealt with, and to see whether these methods could be applied on a large scale. These investigations have now been made, and methods have been devised which seem to make it possible to destroy the bug

on a wholesale scale and to prevent serious damage from it in the future.

Description of the Bug and its Habits.

For a detailed technical description of the characters of the groundnut bug at every stage, we would refer the reader to the appendix. But in the present place it may be stated that the adult bug, whether male or female, is about one-third to two-fifths of an inch long (9 to 10 mm.), and its general appearance is well shown in Plate I, Fig. 6. In this winged stage, its head is black and the rest of the body and legs a yellowish-brown colour. When seen among a mass of groundnuts these winged insects are accompanied by multitudes of the young wingless forms, whose appearance is shown in Plate I, Figs. 1—5.

If fields of groundnut are visited in September or October before the cold weather and before the plants are reaped, stray specimens of the bugs will be found and can be caught, under the plants and in cracks in the ground, both in the adult and in the immature stages. Similarly they can be observed in fields of *til* or sesamum at this time. They hide by day in cracks in the soil, among clods of earth, and under dry twigs and rubbish, collecting especially along the hedges bounding the groundnut fields. As the cold weather advances, they rapidly increase in numbers, and along with the harvested crops they are conveyed to the threshing yards.

The method of harvesting *til* and early groundnuts affords ample opportunities to the bug to be taken easily to the yards where they do their greatest damage and where they can breed in enormous numbers. *Til* is uprooted, tied into bundles, and is left standing in the fields in an upright position. The bugs from all around the fields apparently collect in such bundles, and are thus carried into the threshing yards. Groundnut, on the other hand, is uprooted and the whole including vines, stalks, and nuts are left for a time in the fields to dry partially, and then the crop is carted to the threshing yard.

In the yard the bugs manage to feed on the oil-seed crops mentioned, but they also collect under heaps of other harvested crops which are brought home and stored there.

They have been found in large numbers under the drying heaps of various crops until February and March, after which time they decrease in numbers. Sufficient may be found, however, as late as May, hiding under leaves or any other sort of similar dry material.

Previous experience with these bugs, as destructive agents has been collected by Distant and by Lefroy*. The former quotes De Niceville as having found them damaging the *til* or sesamum crop in the winter of 1900-01. Lefroy evidently doubts this record and writes as follows:—
 “Niceville’s observations as to the injury caused by the insect has never been confirmed and apart from this one instance these insects have not been recorded as injurious. They have, however, been found to infest threshing floors and to carry off the wheat grains to the margins of the floor and hide them. What nourishment they can extract from a dry wheat grain seems doubtful, unless their salivary excretion has solvent powers, but they carry off the grain so abundantly that the cultivators require to collect them again every morning.”

In the case of groundnut there is no doubt about the bugs actually attacking the seeds. They bury their proboscis in the oil-seed, and the result is a diminution in the percentage of oil. In order to be certain of the last fact, samples of groundnuts were sent for analyses to the Agricultural Chemist to the Government of Bombay. Three lots of the same seed were sent, the first being one in which the attack had just begun for two or three days, the second one in which the bugs had been active among the seed for a week, and the third being the unattacked sample. The percentage of oil in the kernels were as follows:—

Oil.

	Per cent.
Unattacked seed	... 49.65
Seed attacked two or three days	... 47.60
Seed attacked a week	... 44.75

These analyses speak for themselves. There is a decided diminution in the oil in the seeds attacked by the bugs. These samples were from a threshing yard where the groundnuts were drying after harvest.

*See Distant, Vol. II, page 79.

The diminution of the oil was important, but a still more serious matter in the Konkan, where the seeds are used almost entirely for eating, was the bitter and rancid taste of the nuts attacked by the bugs. The appearance of the attacked nuts was quite characteristic. The thin skin on the seed became loose, the seed itself appeared wrinkled, and when the halves are separated, and the skin removed, yellow patches are found on the surface. Moulds are usually seen starting from points which were believed to be punctures made by the insect. The punctures, however, were not visible under a lens. The difference between the composition of kernels so attacked and normal ones from the same lot is shown by the following analyses :—

	Normal kernels.	Attacked kernels.
	Per cent.	Per cent.
Moisture ...	3.20	4.20
* Oil ...	49.65	37.20
† Albuminoids ...	30.88	27.50
Soluble Carbohydrates, &c. ...	11.97	24.70
Woody Fibre ...	2.10	3.30
‡ Ash ...	2.20	3.10
	100.00	100.00
* Acidity of oil (in mgms. of Caustic Potash per gram of oil).	1.90	10.00
† Containing nitrogen ...	4.94	4.40
‡ Containing sand ...	0.16	0.20

In supplying the above analyses, Dr. Mann remarks as follows:—“There does not seem very much difficulty in accounting for the change in the composition of the attacked groundnut seed. The attack by the bugs has set up fermentations in the seed which have led up to the destruction of the oil and the production in its place of substances which are found under the heading ‘Soluble carbohydrates, &c.’ in the analyses. What they are I do not know. Some are

acid substances, some appear to be bitter tasting bodies, but I have not examined, so far, the nature of these bodies. The essential point is that a very large amount of oil disappears ; there is a great increase in the acidity ; and the nuts acquire a bad taste."

The reduction in the oil percentage is not always so great as above recorded. Some-time after the above analyses were made a bamboo bin containing groundnut at the Bandhan farm was discovered to be full of bugs. The groundnuts in the bin were fully one year old, and had, therefore, been attacked for two seasons. The extracted kernels showed still, however, 47·7 per cent. of oil, against a normal of about 49 per cent. They were bitter and mouldy, and the shrinkage was very marked. This shrinkage can be more or less measured by the proportion of kernels to shells. In the same variety (Spanish peanuts) the proportion is normally:—Kernels 80·5 per cent.: Shells—19·5 per cent. In the present case it proved to be:—Kernels 66·7 per cent.: Shells—33·3 per cent. At least a reduction of one-third in the weight of the nuts is obvious from these figures.

The effect of the attack on the germinating power of the groundnut seeds was found to be considerable. Attacked seeds, which had been badly affected for nearly three months, gave only a germination of 56 per cent., while the same seed not injured by the bugs gave a germination of 98 per cent.

In general, therefore, it may be said that the attack of the bug reduces the value of the seeds in three ways. It destroys their germinating power, it reduces the percentage of oil in the nuts, and it brings about a bitter and rancid condition. If it had been only a matter of losing some of the oil, it would not have been at present a matter of much importance so far as the Konkan is concerned, for the cultivation of groundnut is limited there, and almost the whole of the produce is consumed locally for eating, either in the raw or in the parched condition. These nuts, however, form an important ingredient of some common dishes locally consumed, and the bitter and rancid nuts have no market for this purpose. The cultivation is, however, slowly extending and will extend if the ravages of the groundnut bug and certain other pests can be prevented, and it may form one of the staple products of the Konkan where no other oil seeds are grown.

Feeding Habits of the Bug.—The bugs are found in all sorts of situations in and round the threshing yards. Actively breeding bugs are found in inconceivably large numbers particularly under the heaps of groundnut fodder. They avoid light, however, in a remarkable way. The whole of their life is spent in darkness or in semi-darkness. The only time when they have been active and on the wing was at dusk, when they fly with a swiftness hardly to be expected of an insect usually so much hidden away. In the fields the bugs find places to hide in the cracks of the soil, under sticks and leaves, and under the spreading vines of the groundnut plants which completely cover the ground. In the heaps of the groundnuts or of groundnut vines or other fodder, they may be found wandering about on the top fully exposed to light, but on the approach of anyone or on the slightest noise, they noiselessly creep away and are no more seen. When they are hiding under dry leaves, the rustling sound they produce when moving inside the heaps can be heard distinctly. The bugs seem to use their legs rather than their wings in their attempts to escape from their enemies. They are very swift on their legs, and move without a sound. Their form and colour helps to hide them in the rubbish under which they are most commonly found.

The bugs may be expected to derive some nourishment from the drying groundnuts in threshing yard, but the dry vines and their leaves continued to harbour them in very large numbers long after the groundnuts themselves had been removed from the threshing yards. Of course, a small number of nuts may still be left sticking to the vines. Exactly how they can live even on these is, however, at present a mystery unless, as Lefroy suggests, the bite of these bugs has a solvent effect in the materials they puncture. Bugs, as a rule, whether they suck the sap of plants or the blood of animals, can only live on liquid food, and their mouth parts are only suited to this form of diet. To determine whether groundnut bugs could live on the oil of groundnut seeds only, a certain number were enclosed in a breeding case with groundnuts in the pod, previously thoroughly sundried. In this case they only lived six days and then all were found dead. This was repeated four times, always with the same result. It thus appears that though the bugs can suck up oil and can live on it for a time, they need other things to support life normally.

A further lot of bugs was then enclosed with groundnuts soaked in water for a day to see whether in presence of moisture they could live and breed normally. Even then the bugs only lived a few days, and in no case was it possible to induce the bugs to live upon groundnuts only. We were able to get the young bugs to pass through two moults when fed with germinating seeds, but even then freshly germinated seeds had to be given each day.

If, however, the bugs were in large cages and were supplied with growing groundnut plants in pots, they lived comfortably and the whole life-history of the insects could be observed without any further trouble. As it was found difficult to get a large number of groundnut plants of a suitable size for feeding the bugs, other plants were substituted. Cabbage seedlings were found to do excellently for the purpose. The bugs grew equally well when supplied with these plants, and we were not able to mark any difference either in the size of the insects or in the length of their life as a result. This point is of peculiar interest in connection with other seed-eating bugs, like some of the bugs of cotton bolls (*Dysdercus cingulatus* and *Oxycarenus laetus*). The former have, in fact, been seen to carry the seeds of cotton far out of the fields to feed upon them in peace. It may be that in these cases too that the oil of the seeds may have to be supplemented by other articles of diet to sustain life normally.

To return to the bugs as they are found in enormous numbers in the threshing yard under heaps of any kind of produce, where they not only stay but also breed. Among other such places they were found under large heaps of *bajri* (*Pennisetum typhoideum*) heads spread in the threshing yards. The grain on these heads was thoroughly dry and the stalks contained nothing but dry pith. The bugs were seen to be lodged comfortably under these heaps, and the eggs and young immature bugs of different stages were found together. When, however, the bugs were transferred to a cage with the same kind of material, the bugs rapidly died. A similar result occurred when they were caged with dry *til* (sesamum) stalks among which they were found in great abundance. When these *til* stalks were spread out they showed innumerable moult-skins and quite a large number of eggs thrust into the half-open pods.

We are therefore entitled to ask whether the *tiz* stalks and the *bajri* heads afford only a hiding place for the bugs, and if so, what is actually the source of food for the growing insects. In order to get light on this question the following observations were made. All the material which sheltered the bugs round the threshing yard was thoroughly shaken, and far removed from the place, so leaving no produce in which they could live. Under these circumstances the bugs took refuge under heaps of stones round about the yard. The threshing yard continued to be used for its legitimate purpose, and grains and pulses were drying in small heaps, but the bugs continued to breed under the heaps of stones. Within a week, the undersides of the stones showed moult-skins sticking to them. The removal of straw and other refuse had, in fact, reduced the number of bugs considerably, but as many as could hide under the stones were accommodated there.

The following notes are from a report made on the spot by the Junior author in the second week of January:—

“I have been visiting the farm every night from 8 to 10 p.m. The movement of the bugs from 6 p.m. are as follows: As soon as the sun goes down, and twilight occurs, they come out of their hiding places and freely wander in search of food. Many of them fly away to a distance. Up to this time I had not marked the remarkable powers of flight of this bug, and I could not chase them to their destination. Many of them when on the wing are preyed upon by the king crow. These birds always hover about near a stack of rice straw at twilight, from which large numbers of bugs emerge. The bugs, in fact, were noticed to fly out of this stack at twilight and not from a bin of stored groundnut though both were situated side by side. The flight continues for an hour or so, and stops when it is completely dark. From that time the feeding of the bugs goes on over all the area near the threshing yard till 6 a.m.”

A few days later, the report continues. “The number of bugs at night seen outside the threshing yard is appalling, and a green patch of grass near the stored groundnut is filled to the extent of a couple of hundred bugs per square foot. They are seen with their beaks embedded in the succulent stems and leaves of grasses such as *hariali* (*Cyanodon dactylon*) and *gulchabu* (*Polygonum tuberosum*). One evening specially, cabbage leaves were kept on a piece of clean-swept

ground, and at 9 p.m. the patch was full of bugs." Every week's report from this time onward contained references to the feeding of the bugs on grass patches on the farm. When the grass dried up, and afforded no further succulent food, the bugs were found to feed on the ripe fruits of the banyan tree (*Ficus bengalences*) which drop in large numbers on the ground.

Remedial Measures.

The damage done by the groundnut bug to the nuts under storage in the years 1916 and 1917 was very great indeed to the Kolaba district. The crop as reaped from the field must be left exposed to the sun in a threshing yard in order to dry as it is impossible to store it in any but the completely dried condition. The damage, and the difficulty of dealing with the pest at first, gave a heavy check to the extension of the growth of the crop on the uplands ('*Varkas*' lands) suited to it, and it was quickly obvious that the success of any attempt to introduce its cultivation on a large scale would be determined by the success attained in dealing with this pest of the threshing yard.

At first sight it looks quite an easy matter to destroy the bugs. The heaps of drying groundnuts would seem to need simply to be raked once or twice every day, when the bugs will run away. That the bugs will disappear temporarily under these circumstances is true, but they hide in the immediate neighbourhood, and return in the evening or following morning, and the next day the heaps will be found as badly infested as ever. Besides the bugs feed particularly at night and it is therefore particularly necessary to prevent them visiting the threshing yard at that time and laying eggs and breeding there. To do this, is, in practice, by no means easy, especially when, as is usually the case, all round the threshing yard are situations in which the bugs are comfortable and quite content to hide. We have, however, succeeded in dealing with the situation and the methods adopted seem calculated to get rid of an attack by the bug when it again occurs.

Early precautions against the bug were taken at the time of harvest. The plots of groundnut to be harvested were first surrounded by a ring of dry grass. The groundnut was then uprooted, the whole plants shaken well to cause the bugs to drop, and carted straightway to the threshing

yard. The bugs remaining in the field were found in by far the greater proportion to take refuge in the ring of dry grass round the field. In the Konkan, at the time of harvesting the groundnut and on *varkas* lands, the grass required for thus ringing the plot can nearly always be had for the cost of cutting and carting it. The grass was now fired at several points, and thus the greater part of the bugs already in the field are destroyed. Practically only a few winged bugs escape. The whole operation cost Rs. 1-8-0 per acre.

The next precaution was to remove the vines and leaves of the groundnuts as far as possible from the precincts of the threshing yard. Once the yard gets thoroughly infested it is exceedingly difficult to get rid of the bugs. The heaps of groundnuts if they now become infested should be dealt with immediately. They can be shaken or raked over after surrounding the yard with dry grass, and after the bugs have taken refuge in the grass this can be burnt as before described. This method is, however, somewhat dangerous in a threshing yard, and very great care has to be exercised not to set fire to other produce kept in the neighbourhood. The firing can be dispensed with, however, as we found, if the grass is tied up in bundles and these arranged systematically round the heaps of groundnut. The heaps are then raked so as to drive the bugs to the shelter of the grass bundles. The bundles are then beaten over one or two poles placed over a tank or vessel containing water, with kerosene floating over it. The operation of beating the bundles is shown as a photograph on the occasion when almost all bugs were killed by trapping them in bundles of *til* stalks which were available in large quantities at the time on the farms. The bugs in fact hide better in these bundles of *til* stalks than in bundles of other grass or *kadbi*. The photograph shows the *gul*-boiling pan used to drown the bugs but any form or shape of shallow vessel will answer the purpose.

Another method which gave a temporary relief from the bugs was spraying the yard with crude oil emulsion. The smell kept the bugs away for two or three days but they returned again. Any method, however, which only aims at driving the bugs away temporarily should be discarded. The bugs swarm back as bad as before as soon as the disturbance which drove them away is removed. When the nuts are dry the clean nuts should be bagged and the mouths of the bags sewn up with great care so as to prevent even the smallest nymphs creeping into the bags.

APPENDIX I.

TECHNICAL DESCRIPTION AND LIFE HISTORY OF THE GROUND-NUT BUG (*Aphanus sordidus*).

The bug (*Aphanus sordidus*) is described by Distant as follows:—

“Head and anterior lobe of pronotum, base of scutellum and sternum piceous or dark castaneous, abdomen beneath pale castaneous, posterior lobe of pronotum, scutellum excluding base, and corium, ochraceous, thickly punctured with brown, lateral margins of pronotum and corium with only a few coarse punctures, apex of scutellum luteous, legs ochraceous, femora, excluding bases, and the tibia punctured and mottled with brown, membrane fuliginous with a dark castaneous spot at base; antennae pale ochraceous, apex of third joint infuscated, fourth joint fuscous with its base luteous, rostrum ochraceous, basal joint castaneous, the apex piceous, lateral and posterior margins of prosternum, two spots on posterior margins of metasternum, margins of acetabula, and lateral marginal spots to abdomen luteous Length 9 to 10 mm.

Hab:—Assam, Naga Hills and Bengal; Ranchi (Irvine), Calcutta. Bombay (Leith). Bor Ghat (Dixon). Ceylon (Green), Burma, Mandalay, Karennee, Prome (Fea) Minhla (Comotto), Tenassarim, Thagata (Fea), China. Also recorded by Stal from Guinea.”

The sexes can easily be distinguished by an examination of the hind end of the abdomen. The last visible segment of the female is triangular in shape when seen from the side (*vide* Fig. 1, Plate II) while in the male it is rounded (*vide* Fig. 4, Plate II). In the female it presents a long slit-like opening down the middle and in this slit is concealed the long ovipositor. By slightly pressing the abdomen of a live specimen this ovipositor is pushed out of the slit which accomodates it. By teasing this extended part with a needle it will be found to be bent double on itself. Under the microscope it can be easily dissected and is shown to be made up of two flaps, one upper and the second lower, which when approximated together leave a channel-like opening for the passage of eggs. The halves of the doubled up ovipositor probably represent the dorsal and ventral plate, respectively of the 7th and 8th segments of the abdomen. They are modified to form the ovipositor. The seventh segment has not undergone any large change in shape. It is nearly of the same shape as the last visible segment and occupies a position just below it when the ovipositor is retracted. The two pieces represent no doubt the ventral plate of the seventh segment and the thin membranous fold of chitin stretched between these two triangular pieces forms the lower boundary of the ovipositor. The dorsal plate of this seventh segment is mostly membranous with only the sides thickly chitinized. The eighth segment is represented by the distal half of the ovipositor. The upper and lower plates are comparatively more membranous than the seventh segment

with the sides only chitinized. The long ovipositor suggests the possibility of the bug laying its eggs thrust into chinks or narrow spaces but it will be found that the eggs are laid in all sorts of situations.

The male genital organs have to be carefully dissected to show the structure clearly. The last visible segment which is globular conceals a spirally coiled penis on either side of which are seen two accessory plates. At its root the penis is slightly widened into a funnel shaped opening into which is found the ending of the ejaculatory duct. The ejaculatory duct traverses the whole length of the last segment of the abdomen which is completely hidden inside the last visible segment. The seminal vesicle is round, from the lower end of which the ejaculatory duct commences. Copulation takes place end to end and not one above the other.

The eggs.—Eggs are one millimeter long and half a millimeter broad. They are rounded at the ends and present no sort of sculpturing on their surface even when seen under a microscope. They are dull white when freshly laid but turn brown within a couple of hours. A few days before hatching they turn pink in colour. Average of five trials have given nine days as the period required for hatching. Normally the eggs are laid in or near the breeding grounds. When the groundnuts are drying in the threshing yards the bugs breeding in these heaps were found to lay their eggs in the soil. The soil has only to be sifted to secure the eggs. Among the *til* (*sesamum*) stalks in which also they were found breeding the eggs were found thrust into the dry or green pods. On one occasion when they were breeding in dry rice straw, bundled and stacked in a corner of the threshing yard, the eggs were found laid promiscuously in the bundles and by shaking these bundles on a clean sheet of paper the eggs could be easily secured. When again the bugs were found breeding among *bajri* (*Pennisetum typhoideum*) heads they were thrust in the heads. This was the easiest means by which they could be secured for laboratory purposes. Adult bugs were imprisoned in a cage with a few dry *bajri* heads. The next day they were shaken and the eggs were secured.

Life History.—The eggs when hatched present a slit at one end. The larva is perfectly pink. Within a short time the head and prothorax darken. The size of newly hatched larvæ is $1\frac{1}{2}$ mm. The head and prothorax are black, meso-thorax is yellowish. Two linear brown patches occupy the sides of the meta-thorax, which is yellow.

Abdomen yellow with the hind margins of segments sanguineous. Three small slightly long glandular patches on the dorsum, black. Eyes red.

Length of first femur.—5 mm. A blunt spine is visible at the distal end of femur.

Length of antennæ 1.2 mm.

Larva of the 1st moult.—Number of days taken to pass 1st moult—5 days.

Length $2\frac{1}{2}$ mm. Length of first femur—64 mm. One spine visible as during the last instar. Length of antennæ—1.6 mm.

Head, prothorax and mesothorax black. Sides of mesothorax ochraceous, metathorax ochraceous with the black patches more horizontal and very nearly meeting in the centre. The patches are rounded off on the outer angle.

A pyramidal ochraceous patch develops behind the thorax and ends with the first glandular mark. Two oval patches of the same colour develop between the three glandular marks. Sides of the dorsal segments are marked pink.

Nymph after 2nd moult.—Number of days taken to pass second moult—4 days.

Length $3\frac{1}{2}$ mm. Length of first femur—9 mm. Two blunt spines visible on the femur. Length of antennæ—2.3 mm.

Prothorax as long as the head, meso-thorax two-thirds the size of prothorax. The horizontal black patches on the meta-thorax, pointed at the outer angle, and nearly meeting in the centre. Colour of abdomen light ochraceous with the hind borders of segments pink. Markings on the dorsum, same as in the last instar.

Nymph after 3rd moult.—Number of days taken to pass the third moult—5 days.

Length— $4\frac{1}{2}$ mm. Length of first femur—1.4 mm. Three blunt spines are developed at the distal end. Length of antennæ—3.4 mm.

Prothorax as long as meso-thorax, meta-thorax partly concealed by the wing pads which are very prominent and rounded behind. Colour markings same as in the last instar.

Nymph after 4th moult.—Number of days taken to pass the fourth moult—6 days.

Length— $5\frac{1}{2}$ mm. Length of first femur—1.8 mm. Five blunt spines are visible on the front femur. Length of antennæ 4.4 mm.

Scutellum is developed and is transversely ribbed. It is blunt and rounded behind. Wing pads are fully formed and occupy the sides of the meta thorax on either side of the scutellum. Meta-thorax is seen only as a narrow strip between the wing pads. Colour markings the same as in the last instar.

Adult after 5th or the final moult.—Number of days taken to pass the fifth moult—9 days.

Length of the body—9 mm. Length of the first femur—2.3 mm. Six spines are developed on the first femur, some are blunt and some more pointed. Length of antennæ—5.1 mm.

The whole life history of this bug extends to 38 days under artificial conditions of the laboratory. Under normal conditions in the field it might possibly be much shorter. The bugs are found actively breeding from September to April and they may pass through 6 or 7 generations before their numbers begin to decrease visibly. The bugs must be capable of laying a large number of eggs as is evidenced by the huge numbers found under the drying heaps of groundnuts and other farm produce. A large number of gravid females have been dissected and the number of well formed eggs found in the ovary ranged between 18 to 32. All attempts to find out the maximum number of eggs that a female could lay have failed. A hymenopterous parasite was however reared out of the eggs during December and January and although the parasites were on the ascendency for a time further observations failed to show that they exercise any definite check on the bugs. Frogs were found concealed under a heap of groundnut fodder under observation. The contents of the stomachs of these frogs showed that they fed freely on these bugs.

Plate I

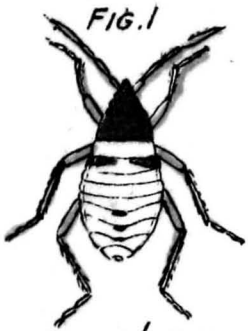


FIG. 1

SIZE. $1\frac{1}{2}$ M.M.
MAG. 14 TIMES.

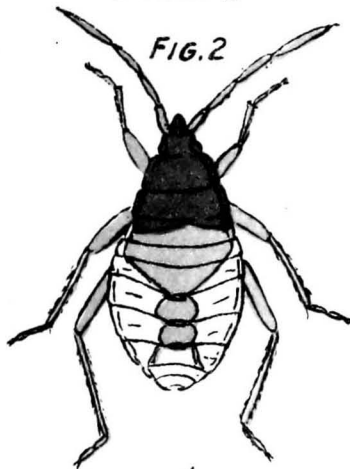


FIG. 2

SIZE. $2\frac{1}{2}$ M.M.
MAG. 12 TIMES.

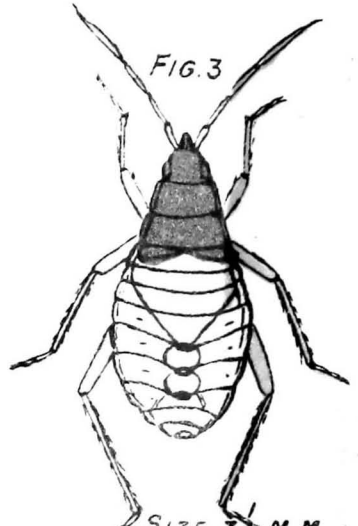


FIG. 3

SIZE. $3\frac{1}{2}$ M.M.
MAG. 10 TIMES.

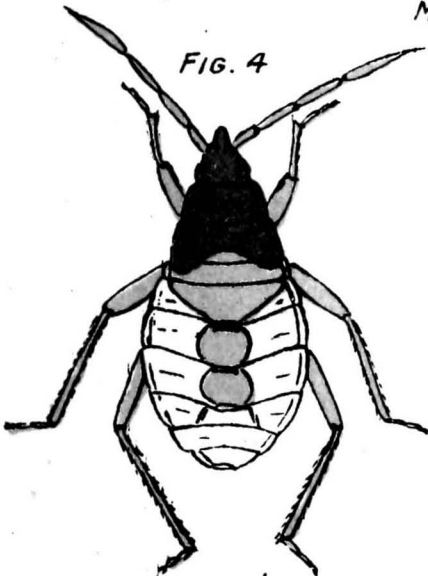


FIG. 4

SIZE. $4\frac{1}{2}$ M.M.
MAG. 9 TIMES.

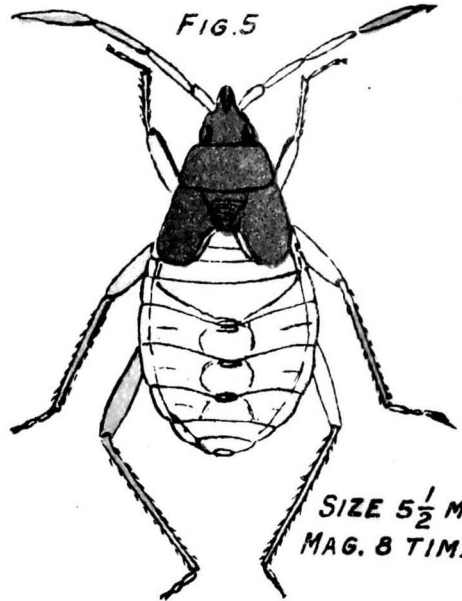


FIG. 5

SIZE. $5\frac{1}{2}$ M.M.
MAG. 8 TIMES.

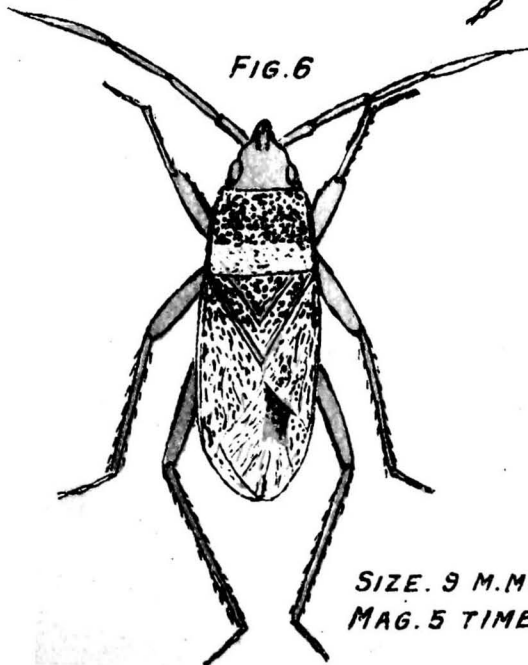


FIG. 6

SIZE. 9 M.M.
MAG. 5 TIMES.

Plate I.

Fig 1. Appearance of the newly hatched bug.

*Fig 2, 3, 4 and 5. Bugs after first, second, third
and fourth moults.*

Fig 6. Adult bug after the fifth or the final moult.



FIG. 1



FIG. 2



FIG. 3



FIG. 4



FIG. 5

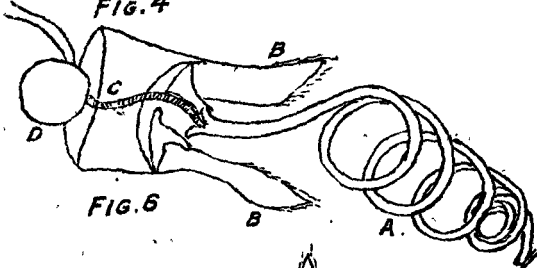


FIG. 6



FIG. 7



FIG. 8



FIG. 9

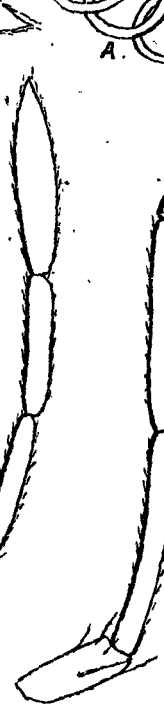


FIG. 10



FIG. 11

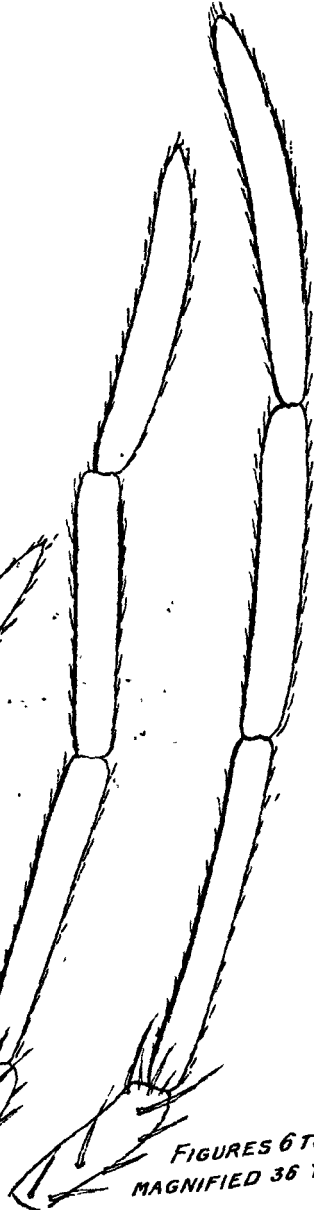


FIG. 12

FIGURES 6 TO 12 ARE
MAGNIFIED 36 TIMES.

Plate II.

- Fig 1. Side view of the last abdominal segments of the female.
- Fig 2. Side view of the last abdominal segments of the female with the ovipositer partially extended.
- Fig 3. Side view of the same when dissected under the microscope showing the upper and the lower flaps of the ovipositer.
- Fig 4. Side view of the last abdominal segments of the male.
- Fig 5. One of the flaps of the ovipositer showing the tip deeply indented.
- Fig 6. Genital organs of the male:— a, the coiled up penis b, the accessory plates, c, ejaculatory duct, d, seminal vesicle.
- Fig 7. Size and shape of the segments of the antenna of the bug soon after hatching from the egg.
- Fig 8, 9, 10 and 11. Same after first, second, third and fourth moults.
- Fig 12. Same of the adult bug.
- Fig 6 to 12 are drawn under Camera Lucida and are magnified 36 times.

Plate III.

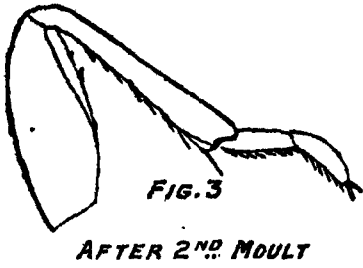


FIG. 3
AFTER 2ND MOULT

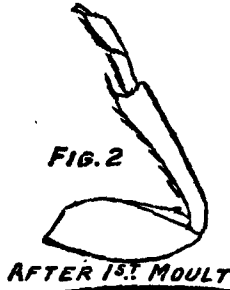


FIG. 2
AFTER 1ST MOULT



FIG. 1
FEMER AFTER HATCHING

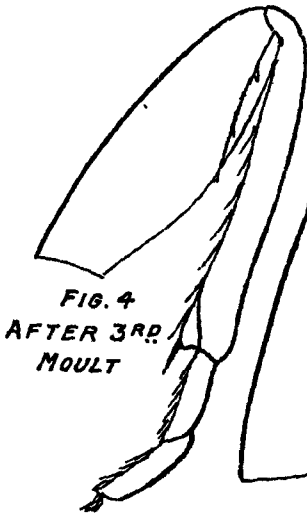


FIG. 4
AFTER 3RD MOULT

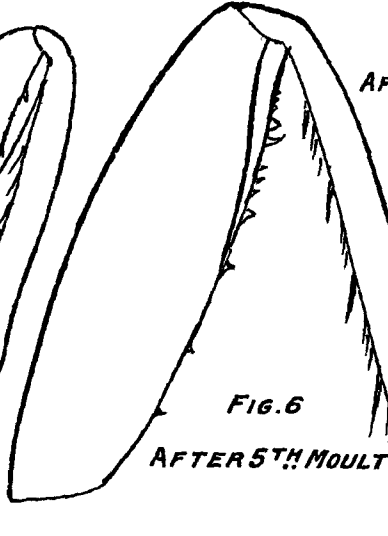


FIG. 6
AFTER 5TH MOULT

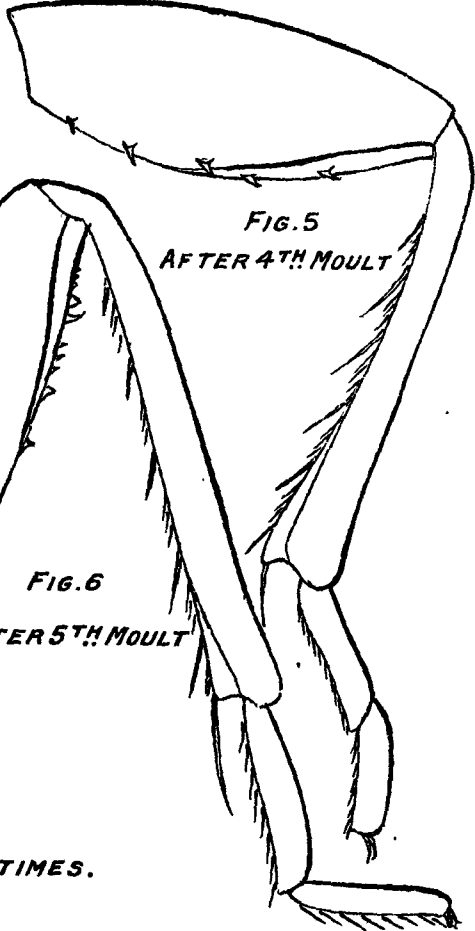


FIG. 5
AFTER 4TH MOULT

ALL FIGURES MAGNIFIED 36 TIMES.

Plate III.

Fig 1. Size and shape of the first femer soon after hatching from the egg.

Fig 2, 3, 4 and 5. Same after first, second, third and fourth moults.

Fig 6. Same after the fifth or the final moult.

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**FRUIT CULTURE IN PALITANA
AND JAMNAGAR**

BY

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PREFACE

IN September last Mr. Dadubhai P. Desai, Zamindar of Nadiad, wrote to Dr. Mann that Mrs. Tudor-Owen had reared a grape and orange orchard at Palitana and that after long and patient work had come to definite conclusions as regards these fruits. In order that the experience gained there might be taken advantage of in the neighbouring tracts of Gujarat, Mr. Dadubhai proposed that an expert officer of the Bombay Agricultural Department might be deputed to Palitana for a thorough study and examination of the orchards and for publication of his results for use of cultivators. I was accordingly deputed for the purpose, and the following pages are the result of the investigations carried out.

(Signed) G. B. PATVARDHAN.

Poona Agricultural College,
May 5, 1920.

FRUIT CULTURE IN PALITANA AND JAMNAGAR

VINE AND ORANGE CULTURE IN PALITANA

During the minority of His Highness the Thakor Saheb Bahadursingaji, the Administrator of Palitana and his wife had undertaken the development of fruit culture, especially vines and oranges, with a view (1) to equip the Thakor Saheb's palace with a home fruit garden containing selections of high grade varieties of fruit, (2) to make trial introduction of these fruits and others in Palitana, (3) and ultimately to interest local farmers in their possibilities. About ten years ago, soon after the completion of the building of the Hava Mahal palace, a site within the precincts of the palace compound was selected. The grounds on which the palace is situated are on a low plateau overlooking the village. The garden is located on the south of the palace with a clear eastern aspect—a situation not unfavourable to a fruit garden. The situation itself precluded the existence of any deep soil but guaranteed free drainage.

Soil.—The area has a reddish black very light soil about a foot deep, overlying a reddish white murum layer eighteen inches to two feet deep. Below the latter is a loose disintegrated hæmatitic trap layer. When the area was undergoing preliminary preparation, the soil on it was added to by that brought from the foundations dug for the palace. The surface of the land is level. The soil is on the whole very friable, well drained and neither too rich nor extraordinarily retentive of moisture. A chemical analysis of it is given below :—

Loss on ignition	..	..	5·70
Sand	..	..	42·83
Lime (CaO)	..	..	1·70
Phosphoric acid	..	..	0·23
Potash	..	..	0·12
Nitrogen	..	..	0·08

Climate.—Palitana is situated just about 21·5° N. Lat. and 72° E. Long. The climate is hot and dry for a long time of the year. The average (of three years 1913—1916) maximum temperature in April and May is between 100° F. and 105° F. The maximum temperature is above 90° F. for nine months in the year. The lower maxima are in December, January and February in which they range between 82° F. to 85° F.

Rainfall.—The average rainfall at Palitana is between 22—25 inches. It is confined to June, July, August and September with a little (average 0·75 inches) in October. The other months are quite dry. There is no chance of ante-monsoon precipitation. Frosts, however, are occasionally feared, but there is no certainty of their annual regular occurrence.

The climatic and soil factors bring very prominently before the mind's eye those obtaining at Jeur and Pimplegaon Ujjan in the Ahmednagar district where grapes are so successfully cultivated under exactly similar circumstances as to soil, temperature and rainfall.

Temperature.—The maximum is in May when it rises to about 110° and the minimum is 56° in December.

Water.—The land is commanded by irrigation which is delivered by pipe water supply derived from a special reservoir which provides water for all purposes in the palace. The water is available at any required time. The following chemical analysis of it shows that the water is suitable for fruit crops :—

	Parts per 100,000 parts.
Total soluble salts ..	60·00
*Containing :—	
Calcium Carbonate ..	22·64
Calcium Sulphate ..	3·51
Calcium Chloride ..	1·73
Magnesium Chloride ..	20·65
Sodium Carbonate ..	2·12
Sodium Chloride ..	2·51

* This analysis was kindly supplied by the Agricultural Chemist to the Government of Bombay, Poona.

Vines.—There are three plots ; of these the first of 110 plants is on the site indicated above, the second of about 100 plants on another piece of land close to the western boundary line of the palace ornamental gardens, and the third at Ambawadi two miles to the south of Palitana town. I am referring to the first of these in what follows. The others will be mentioned later.

The vines are planted $9\frac{1}{2}$ feet apart with a distance of 15 feet between the rows—thus the area occupied by the grapes is very nearly one-third of an acre. They are trained on the espalier system. Two wires are stretched along the line of plants, the lower one 2 feet 9 inches from the ground and the other 18 inches higher pass through small masonry pillars and are tied beyond to strong iron posts with proper tightening arrangements. The plants stand in the centre of a shallow circular bed of 5 feet diameter and water is given from channels one of which runs in front of each row.

Planting.—The vines were planted eight years ago in pits 3 feet wide and 2 feet deep which were dug and filled with fresh surface soil, bonemeal, fish and farmyard manure six months before planting.

Nursery Stock and Varieties.—The plants were obtained from Mr. Paul of Bangalore who got them from his Australian nurseries. The varieties represented are :—(1) Sweet Water, (2) Muscatel, (3) Black Hamburg, and (4) Sultana.

Pruning and Training.—Initial pruning operations commenced as soon as the plants became established and put forth vigorous growth. The lower 24 inches of the vine was freed of all shoots which appear incessantly in that region of the vine. From this height the stem bifurcates into two arms, the point of bifurcation being styled the head of the vine. The two arms were allowed to grow along the lower wire for about two feet and thus form two arms. Any further extension of the arm is stopped by pruning the end of it. Laterals borne by the arms are spaced at regular

distances on the arms. The laterals are pruned annually to 3 or 4 buds in December. The shoots emerging at the end of the laterals bear the inflorescence on the fourth or fifth node. The shoots are tied vertically to the upper vines and thus the weight of the fruit does not cause any strain on the young shoots. This is the vertical system of training mentioned by Bailey. Flowers appear in January and the fruits are harvested in April and May. The tips of bearing shoots are pinched between February and April. From May to December the shoots continue their vegetative growth onwards till the next year's pruning in December. These continuation branches are not tied to wires but are allowed to have their way and twist on the wires or fall on the ground. This growth may become 10 to 30 feet long during the interval. In December the cane—the shoot which had borne fruits—is cut in the middle of the inter-node next in front of the fruit bearing node. As a result new shoots emanate from buds in the axil of the leaf opposite the position of the harvested bunch. These shoots bear flowers in the next year.

As a result of the one annual pruning we find (1) the fruit is borne on young shoots appearing on one year's wood, i. e., the flowering shoot grows out of a bud which was formed along with the flowering bud of the last year, (2) that the canes of the vines extend by about 6 to 9 inches from year to year. When the extension indicated goes beyond the limits prescribed, the whole is cut back close to the head and a healthy lateral (or a cane one year or two years old) is pulled forward and tied so as to replace the old arm having first being shortened to about one foot in length. The renewal canes may be forming on one side of the vine while the other is bearing as usual. It may happen also that both the arms may need renewal simultaneously. The vines have been trained and pruned in the manner indicated above. Along with pruning the bark is also scraped and removed. The accompanying photograph No. 1 shows

bearing vines at the place. Another No. 2 shows the general appearance of the vine-yard.

Manuring.—Early in December all surface soil round each vine is removed till the first small rootlets appear—the tree is pruned and fresh soil replaces what has been removed ; bulbs of freshly slaked lime is added and thoroughly incorporated with the soil ; then, leaving a space of about a foot in diameter round each tree a mixture of two baskets of well rotted and screned stable refuse and 2 lbs. of bonemeal is carefully incorporated with the soil outside the space. In the last two years three pounds of decorticated cotton seed was added to the mixture. The plant is watered copiously so that it may brim up to the top of the banks. Soon after the soil has dried sufficiently to allow of its being raked, that immediately round the stem of the tree is removed and replaced by fresh soil liberally mixed with wood-ashes. The space close round the stem is not manured because the farm manure would attract white ants and as in watering some of the farm manure might have been carried to the stem, the soil immediately about the stem is removed and replaced by the fresh soil and wood-ashes. All this work is finished before the 24th of December.

Wood-ashes are given after each watering in January and a liberal supply of the same again in November but without watering. Vines are not touched or manured after they have set their fruit ; only the soil is raked after watering from December to close of watering in April.

In addition to the above formulæ of manure, the land intervening between the actual beds and rows is sowed with san hemp (*Crotalaria juncea*) in June. This is ploughed in August and reploughed again and again in September and October.

The above method and times of supplying manure to the roots of the plants, at all needed times indicated the necessity of elaborate and scrupulous attention required chiefly to prevent access of white ants to the collar of the vine.

Irrigation.—Water is given in December along with the manurial dressing as indicated above. In January and onwards till about the middle of April, it is given once in every four days. Immediately after the grapes begin to change colour, *i.e.* about April 10th, irrigation is stopped to allow the berries to ripen. No water is given to any tree after April. From June to December no water should be given unless there chances to be very draughty weather when one watering a month may be needed.

Interculture and mulching.—I have referred above to the interculture of the land between the beds and rows by burying green manure and mulching the soil by monthly ploughing. In addition the circular beds are mulched by lightly stirring the soil in them. These operations help aeration of the soil and keep the ground quite clear of weeds.

In July the vines are earthed up to about a foot or so of their height to prevent any water lodging and to reducing unnecessary growth. The earthing up is said to check too much vegetative growth in the rains.

Enemies.—White ants occurring in the soil are the great unseen odds which must be faced by cultivators in this tract. Frequent dressing of the soil with ashes referred to above under manuring is practised with a good deal of success. The stem actually attacked is scraped, the tunnels being thus removed, while it is washed with a solution of Phenyle disinfectant (three-quarters of a tea cup dissolved in one water can). The solution may be poured in the hollows of a trunk if any are formed by the ravages of white ants. Occasional soaking of the soil with this solution is said to have kept away the insects. It is said that this treatment has given good results.

A good spraying mixture used, if plants are worried by insects, is made by dissolving 7 lbs. of copper sulphate and 5 lbs. of soft soap in 70 gallons of water.

Another mixture used to kill any insects which may be hiding in the bark is prepared by dissolving 1 lb. of sulphate of iron (Ferrous sulphate) in one gallon of boiling water to which is added 2 drams of sulphuric acid. This mixture is applied by means of a swab upon the stem, branch and shoot. This must be done immediately after pruning before any buds have sprouted into shoots and leaf as these would be burnt by the treatment. I think the absence of the much detested beetle (*Scelodonta Strigicollis*) of Nasik is due to the application of this. The mixture is also a preventive against anthracnose. Unfortunately this mixture is too dangerous to be confided to the hands of the cultivators at the present stage of their education.

Fortunately the vine-yard has not been attacked by mildew (*Oidium*). The dry climate, the clean cultivation, absence of any shade and any water stagnation on the grounds and in the neighbourhood have been the saving causes.

Yield.—The vines have begun to yield from the second year. If all were well in these eight years the plants would have become very uniform, large and heavy yielding under the assiduous care of Mrs. Tudor-Owen. But for about five years in the middle the plot happened to be neglected for local reasons and the vines had to be renovated in 1916 on Mrs. Tudor-Owen's return to Palitana. At present they are all healthy, vigorous and yielding.

The second plot of grapes situated on the west of the ornamental garden contains 100 plants treated in all respects except training—like the first one. The supporting wires are dispensed with but the arms are trained on dwarf crosses (+) of wood driven into the ground behind each tree.

This plot was planted in 1917 and has yielded the first crop in May 1919.

The following statement shows the yields of the plots :—

Plot I.

Plant No.	Number of bunches.	Total weight in ozs.	Plant No.	Number of bunches.	Total weight in ozs.
5	2	8	106	16	79
6	8	24	52	10	6
7	7	42	53	12	48
12	1	2	58	5	16
13A	4	6	63	3	4
13B	1	2	107	4	76
14	4	4	86	5	13
15	2	8	54	2	5
16	2	16	91	5	12
18	2	4	88	6	11
23	1	3	91B	1	2
25	2	3	92	1	2
29	2	4	55	4	5
108	7	44	94	2	6
31	2	6	110	3	16
50	6	11	99	16	82
40	6	25	101	11	21
42	8	17	102	22	173
47	16	67	103	25	152
49	9	32	104	4	31
Total.. plants 40				245	1,038

Plot II.

2	4	6	10	2	5
5	4	9	11	4	6
6	1	2	12	5	5
7	6	13	13	5	20
8	6	17	15	5	10

Plant No.	Number of bunches.	Total weight in ozs.	Plant No.	Number of bunches.	Total weight in ozs.
16	5	10	56	4	13
17	4	12	57	5	15
18	1	3	58	7	8
19	2	2	59	1	2
22	3	4	60	1	2
23	2	6	62	4	6
24	6	10	63	2	4
25	5	11	64	1	6
26	3	6	65	6	26
29	2	2	66	8	24
31	1	3	67	4	16
32	7	16	68	8	24
33	5	10	69	6	13
34	3	3	70	2	5
35	5	18	71	6	14
36	3	9	72	4	12
39	1	2	73	7	112
42	4	8	74	6	34
43	3	3	75	6	25
45	3	4	77	3	6
46	2	6	83	1	3
47	5	23	84	3	6
48	3	5	85	3	8
49	8	13	86	4	8
50	11	28	87	7	41
51	5	11	88	5	11
52	5	7	89	9	46
53	3	4	91	2	4
55	10	32	92	2	9
Total . . plants 70				301	1,067

The first plot has given an average of 26·0 oz. of yield per plant though individual plants have yielded from 4 to 10 lbs. The average is not satisfactory. It must be remembered however that the average is taken from a plot which contain plants of three or four kinds and from plants which had received a great check for some years and amongst them there was a varying degree of renovation. Still the yield of 3 to 10 lbs. from some individual plants soon after the first chance of fruiting got after each recouping vigour is decisively encouraging.

The outturn of the second plot only two years old is 15·4 oz. per bearing plant though some individual plants have yielded from 2 to 7 lbs. If the vines were planted 9 feet apart—I consider this distance is quite enough,—and if only 60 per cent. of the plants bore fruit in the next year as was the fact in the present case, still the average calculated outturn of about 325 lbs. per acre is not bad specially so *early in the life of the plantation* and especially where the *fruiting wood* is so small in amount.

Of the varieties planted, “Muscatel” is the best yielder and is also hardy. “Sweet Water” is not of a high quality but is hardy, prolific and early. The black variety is hardy and prolific.

Figures as to cost of cultivation are not available. I make an approximate estimate of it per acre :—

	Rs. a. p.
(1) Labour 300 units at 6 annas a day	112 8 0
(2) Irrigation by hire 32 times at Rs. 2-4-0 each time ..	67 8 0
(3) Six ploughings, <i>i.e.</i> , 12 days at Rs. 1-2-0 a day ..	13 8 0
(4) Manures, etc., about ..	32 0 0
	225 8 0

Income.—For calculating this I take the following basis :—

- (1) About 550 plants per acre.
- (2) About 90 per cent. plants bear fruit.
- (3) That the vine-yard is in the third year which is the first proper bearing age.

(4) That each vine bears only 3 lbs. per plant which is low and is just the outturn of the best plant in the second year only. Normally each plant must give at least 6 to 10 lbs.

On these basis an acre will give 1,500 lbs. which at 6 annas a pound is about Rs. 562. The profit is therefore Rs. 332. The outturn is taken very low. The pruning method which I recommend later will give a large amount of fruiting wood—I think about two to three times the amount now present—and therefore the yield and profits will increase in proportion.

The third plot of vines is very recently planted. It is on a sloping ground with eastern exposure. The plants were put out last rainy season and are progressing well. The soil is perhaps too calcareous. It must be heavily manured with farmyard manure.

Mrs. Tudor-Owen who has taken so much interest in the cultivation of these vines has drawn up a methodical monthly calendar of operations. It is given as an appendix and I consider that it is important to have it here if one has to understand the cultivation of the vine properly.

Conclusions.—The detailed study of the facts of the cultivation mentioned in the preceding paragraphs have caused me to arrive at the following conclusions :—

(1) That vine cultivation in Palitana may be considered to be a decided success.

(2) That high grade varieties such as “Muscatel,” “Sweet Water,” “Black Hamburg” are successfully

introduced into this part of India. We do not grow these varieties in other parts of the Bombay Presidency and the success here indicates clearly their possibilities in other growing tracts of the Bombay Presidency.

(3) That a higher and more uniform yield per plant would have been assured if it had been possible to render continuous attention to the plants.

(4) I concur in Mrs. Tudor-Owen's opinion that the training on wires would be too costly for the cultivators and that they should be trained without them by forming bushes.

(5) That the soil and climatic conditions here are ideal for grape culture.

(6) That the trials have passed out of the experimental stage so far as important points of culture and varieties are concerned and efforts may now be safely made to bring the results to the notice of intending cultivators.

Recommendations.—1. My first recommendation is about supporting the vines. The bushes in the second plot should be trained on a live *Pangara* (*Erythrina Indica*) stem 4 feet high. I propose that the system of training by spreading arms should be retained until it is proved that method of the pruning back (as is done at Nasik) close to the head of the vine at each pruning is agreeable to the varieties. Readily removable cross bamboo sticks may be tied to *Pangara* at about the same height as the wires and the arms trained on them. The live *Pangara* support would give the following advantages among others :—

(a) They will support the vines.

(b) They will admit of ploughing between the trees ; the cross sticks being removed at ploughing and retied soon after.

(c) They will save vertical wooden supports which are likely to rot in the ground.

(d) Since the *Pangara* trees must be pruned three or four times in the year (1) to prevent them shading the vines, (2) to reduce to a minimum their consumption of manure given to the vines by root-pruning, their presence is not in any way harmful.

(e) The *Pangara* leaves on pruning may be fed to the orchard cattle.

2. My next recommendation is about pruning the vines twice in the year. This may look strange to some who read English and American literature on the subject in which an annual pruning is described. But it has been practised by us at the Ganeshkhind Botanical Gardens and by all cultivators of the Nasik and Nagar tracts with so much success that I have no hesitation in recommending it. Besides I do not see the presence of any climatic or other factors here different from that tract. Two prunings should be done, one early in June and the second in December. In the first pruning the cane should be cut back to one or two buds behind the bunches and in the second the branches arising from the buds left in the previous pruning should be shortened to three or four buds which will bear flower and fruits in the next season. This method will provide more fruiting wood than in the one at present adopted and will accord with the fact that the fruit is borne in a few clusters near the base of the growing shoots of the season which spring from wood of last season's growth.

3. The indigenous local variety of Nasik called *Bhokari* should be cultivated along with the ones already tried.

4. More intensive planting should be adopted as to have from 500 to 600 plants per acre. This can be done without detriment to the growth of individual trees but with the possibility of quadrupling the yield.

The recommendations can be adopted at once without the least hesitation as to success,

I proposed to make further recommendations in this matter, *e.g.*, trial at Palitana of some other varieties, alteration of certain details in the methods of cultivation, etc., based upon results of experiments in the Ganeshkhind garden and experience in other tracts not differing in any essential respect as to climate, soil, water, etc., from Palitana. But I desist from doing so as it is not in the province of this Bulletin.

CALENDAR FOR VINES.

This Calendar is adopted by Mrs. Tudor-Owen at Palitana.

July.

Earth up the vine trees so as to prevent any water lodging and so reducing unnecessary growth.

Do not earth up young vines. These must go on growing, and if there is drought, they ought to be watered regularly. As a general rule vines that have borne fruit will not need any artificial watering till after they are pruned and manured in December but if there is a very long drought they may be given water about once a month to keep them alive.

August.

The san hemp should be ploughed in.

September.

Plough the san hemp soil again so that the san hemp may be thoroughly incorporated with the soil.

Treat carefully for white ants in the vine. This is the time when they are troublesome.

October.

Keep on ploughing at least once a month between vines not only to incorporate the decaying san hemp but also to keep weeds and grass, which otherwise take all the fruit tree rootlets which means the health of the tree.

November.

The vines ought to be treated for white ants. See that they have a liberal supply of fresh wood-ashes but no water at all. Pick off old leaves of vines.

Plough once again the san hemp area. See about getting a sufficient supply of bonemeal, decorticated cotton seed and castor cake meal.

December.

See that all pruning scissors and knives are put into good order, also shellac varnish and sulphate of iron and sulphuric acid, for spraying on the vines after pruning.

A very good mixture for spraying is —

7 lbs. copper sulphate,

5 lbs. soft soap,

70 gallons water,

sufficient for 250 vines. Each vine not to have less than two pints.

Only use this mixture if the vines are very worried by insects. Open up all the soils round the vines and remove this to form the banks of the bed till you see the fine rootlets appear. Leave like this for a few days, while fresh soil and manure and slaked lime are gathered together.

(December 18th).—Begin pruning vines. The great secret is to have your canes well spaced, only leaving the healthy ones—those about the thickness of a lead pencil.

New cuttings must be made from those trees that have borne the most fruit. All other pruned branches must be gathered in a heap and burnt and ashes used as manure for the vine trees.

Remove loose bark. Swab down each tree with one pound sulphate of iron dissolved in one gallon of boiling water. Add two drams of strong sulphuric acid, paint all down

the stem, and over each branch and shoot. The tree ought to appear almost white when it dries. This is to kill any insects.

Put fresh soil round each tree, well mixed with 2 lbs. of slaked lime to each tree, leaving a space of about a foot in diameter round each tree, give two basketsful of well rotted and screened stable manure and two pounds bonemeal well mixed, and carefully incorporate it with the soil outside the above space.

See that banks all round are made up very high so that each plant may be watered copiously, the water now is the most important item, and next in importance is the raking of the soil round each tree. Water copiously, it must bring to the top of the banks.

After the soil has dried sufficiently to allow of it being raked, remove the soil immediately round the stem of the tree and replace with fresh soil liberally mixed with fresh wood-ashes. The space round the stem is not manured because the farm manure would attract the white ants, and as in watering some of the farm manure might have been carried to the stem the soil immediately about the stem is removed and replaced by the fresh soil and wood-ashes mixture already mentioned. All this work ought to be finished by the 24th of December.

January.

Vines ought to be budding. See that they have an application of fresh wood-ashes after every watering or else they will be attacked by white ants. If white ants still persist, use a weak solution of Phenyle as a wash for the whole trunk. (One part Phenyle to 60 of water.)

February.

Good month for planting up new vines. See that they are protected from the sun, till new leaves come. Shady

branches fixed round the young plant at intervals will give enough shed and shelter.

Vines ought to be forming fruits. Wherever fruit have formed pinch off the end of that cane or shoot so that all the strength may go to fruit. Have tried this in 1918 with great success. Fruit of canes which have been shortened are markedly bigger than those that were allowed to grow long.

March.

See that vines are well watered.

April.

This is the month when squirrels do a lot of damage to ripening grapes. Mosquito bags to be put on the bunches for protecting the fruit. These ought to be removed once a week so that each bunch may be examined for mildewed and rotting grapes. An application of flowers of sulphur will remove the former and rotting grapes can be removed by tiny pincers.

Immediately grapes begin to change colour about April 10th to 15th stop all watering, to allow them to ripen. The "Sweet water" grapes ought to be fit for the table from about the 20th.

May.

If vine berries do not enlarge quick enough water every day. If vine berries begin to burst in any quantity stop watering even if some of the berries are small. They will sweeten all right.

If any berries rot, remove these very carefully with tiny pincers. When berries show the slightest signs of a change of colour stop all watering to allow of sugar forming. Do not allow any watering at all even near those trees on which berries are ripening. The "Sweet water" variety gives quite small grapes. They ripen long before the others and are delicious. If when watering has been stopped, the leaves

shrivel and look drooping, just give a little water, to buck up the vine, or the ripening fruit might suffer and then again stop watering to allow the fruit to continue ripening.

June.

After all the fruit has been gathered, bank up earth all round the tree upto the main trunk, leaving rather a sharp slope to prevent any water lodging. Bank up earth even if all the fruit has not been gathered, at the beginning of June. No watering is necessary all through the rains, unless of course there is a long drought when the trees will show their need by the leaves drooping and shrivelling when a little water can be given. The trees are banked up to prevent any rain water lodging near the trunk which would only encourage more growth in the vine which we do not want during the rains.

The soil between the vines should be ploughed up. After the first rains san hemp should be sown for green manure. This will keep down weeds and will greatly benefit the soil.

CITRUS PLANTS.

Along with vines some choice varieties of oranges and limes have been introduced into Palitana. These include the following reputed varieties :—

- 80 plants of Australian Navel Oranges.
- 7 Sweet Limes.
- 19 Sour Limes.
- 3 Agra Oranges.
- 23 Sicilian Lemons.
- 10 Delhi Oranges.

The most successful of these are Navel oranges, Delhi oranges and Sicilian Lemons.

All these are planted under the same conditions of situation, soil, water and initial manuring as the vines and in plots adjoining them.

Australian Navel Oranges.—These are now nine years old. They are planted at distances varying from 20 to 22 feet apart between the plants and 17 feet in line. At present they form an umbrella shaped small tree about 12 feet high, and 11 to 12 feet through with 18 to 24 inches of stem below clear of any forking. The annual ground treatment and manuring so far has been as detailed below.

Ground treatment.—Sann hemp is sown in the blank area between the lines soon after the first break of the rains. It is ploughed into the soil in August and monthly ploughings of the land are carried out till the end of November for the purpose of incorporating the rotting sann hemp, suppressing weeds, and aerating the soil.

Beds.—Usually a circular basin about 8 feet diameter is made round each tree though these beds vary in size according to the circumference of the widest part of the tree in individual instances. The basins are connected by a channel which conveys water from a main. The soil in each basin is stirred after each irrigation in order to prevent formation of crust and to prevent evaporation of moisture.

Irrigation.—Irrigation is applied full up to the brim of each bed every 4 or 5 days all the year round with the exception of a couple of weeks in December just before giving manure. After pruning water is given copiously in December and January—a little less in February to let the fruit set and after that copiously every four days.

Manure.—In addition to the green manure referred to above freshly slaked lime is mixed in the soil round each tree in August to kill any Mediterranean flies that may have dropped into the soil to lay eggs. In the first week of January the soil immediately round the trunk is removed and replaced by mixture of fresh wood-ashes and fresh earth. In the third week of January each tree is given seven pounds of decorticated cotton cake and 2 lbs. of bonemeal *plus* 1 lb.

of ammonium sulphate. This is worked in the bed, the manure not being allowed to touch the trunk of the trees.

Flowering.—The trees flower in February when they are so full of blossom that they look as if covered with snow. Frequent dropping of fruits and flowers is noticed. At the time of my visit, I found the Navel oranges set to the size of peas, fruiting very profusely but dropping very considerably. The trees are reported to have had good large fruits in January 1916 but not ripening fast enough. I saw a few stray fruits now on one tree planted near "Delhi oranges" of the past *bahar* (crop) but they had not ripened although they had attained their full size. Mrs. Tudor-Owen says, "Ripe fruit is taken every year in September, October and November. The trees have borne every year since they were two years old with very few exceptions, and decorticated cotton-seed was tried, the fruit was wanting in flavour, being more like a sweet lime than an orange. It was a record crop last year—the fruit of delicious flavour but getting all destroyed by Mediterranean fly.

Enemies.—From what I was told, the plants bore excellent crop last year (1919), the trees giving about 500 fruits each, but most of the fruits were punctured by the white fly known as the "Mediterranean fly" and the fruits dropped. The fruit fly has been identified by Mr. Paul of Bangalore as the Mediterranean fly. The precautions and remedies adopted against this pest are:—

1. Destruction of all fallen fruits found to be infected.
2. Cultivating the ground around the trees six inches deep in order that any maggots fallen down from fruits may be buried, and applying slaked lime on the surface of the beds in order to destroy chrysalids which may happen to be turned up.
3. All affected fruit from the trees are collected and burnt or buried 3 feet deep with the addition of quick lime.

All trees are sprayed with Bordeaux mixture before blooming. The Mediterranean fly *Ceratitis capitata* has not been recorded as a pest of oranges or other fruits in this Presidency. The one that is damaging fruit similarly and is very obnoxious in the Deccan is the moth *Ophideris fullonica* which punctures citrus fruits at night. Attempts were made at the Ganeshkhind Botanical Garden to trap this by means of toddy juice placed in small earthen vessels suspended to branches of trees. Another and more successful plan is to scald the insects by means of torches. The insect usually settles upon the fruit for 15 minutes and is not frightened away by the presence of torch light, and is thus easily killed by burning with the torch. I am of opinion that more accurate identification of the pest at Palitana is needed.

They however happened to be neglected for about 5 years during which time they made too much long wood. Mrs. Tudor-Owen came to their rescue in the meanwhile and trimmed them back into 'balance' by regularly spacing the branches round the trunk. Mrs. Tudor-Owen is very hopeful of complete success of this.

The trees had been very systematically pruned and trained to obtain a certain shape from the beginning. The lower eighteen inches of stem is kept clean. It is then allowed to branch upwards and outwards so as to form an umbrella shape. All suckers and water sprouts are systematically cut away from time to time. If some branches project far out on the top they are removed wholly from the point of origin on the tree, thus admitting light inside the head of the tree and also maintaining a uniform height required for the purpose of maintaining the umbrella shape. Lateral or pendent branches are also shortened back after the harvesting of fruit. The trees are now the picture of health.

Delhi Oranges.—Next to the above are the Delhi oranges so called because the man who supplied them told that he had grown them at Delhi. There are ten plants planted 8 years

ago. All of them are splendid specimens of excellent growth. The variety is different from the Poona oranges. The Delhi orange tree is a large round dome shaped bushy tree 16 to 18 feet high and 23 to 25 feet through, branching profusely, the outer and lower branches almost sweeping the ground. These trees are also pruned and shaped in the same manner as the Navel oranges. They are also manured and otherwise treated like the Navel oranges. The trees are said to have borne enormous crops, and to have done so four times in the 10 years of their life. At the time of my visit, one tree (photo accompanies) had about 400 fruits and I was told that about twice the number had been already harvested from the tree. The fruits are three and a half to four inches in diameter rounded with the usual depression at the stigmatic end and lines or ridges at the stalk end. The colour when ripe is orange, surface, tubercled and furrowed. The fruit is of a most delicious flavour and is tight skinned. The variety is inclined to bear in clusters each containing 23 or 24 fruits.

Sicilian Lemon.—This is a lime. Its fruit is oblong, yellow coloured, having a nipple at the apex. The tree bears very abundantly. The fruit is highly valued for making still lemonade. One meets with this variety in the Deccan though not known under this name nor any other. It is different from the 'Pat' lemon. 'The full size is said to be quite 3 times that of the Indian varieties.' The specimens seen by the writer were not so big.

The trees are now very vigorous looking. They are given the same treatment as the other oranges.

The following is the Calendar regarding Oranges :--

CALENDAR FOR ORANGES.

June.

Before the rain comes give the orange trees 5 lbs. each of well rotted farm-yard manure. Often after rain the orange

trees bloom for a second time, while the fruit of the previous blooming is still not very advanced. This must weaken the tree, and perhaps this may account for some of the fruit being so tasteless. Sow sann hemp soon after the first rain.

July.

No treatment.

August.

The sann hemp ought now to be ready for ploughing in if it is about to flower. Choose a day just after rain—it incorporates better with the wet soil.

Keep a careful watch for the Mediterranean fly in oranges. Destroy affected fruit and mix slaked lime with soil round the trees. The fly is small and drops on to the ground unseen, immediately the fruit is handled.

September.

The sann hemp ought to have decayed by this time. If bullocks can be spared plough all over the sann area again, so that it might be thoroughly incorporated with the soil.

October.

Watch for Mediterranean fly as a precaution. Spray orange trees with Bordeaux mixture if there is any suspicion of Mediterranean fly.

Keep on ploughing, at least once a month, all land between vines, oranges and the sann hemp area, not only to incorporate the decaying sann hemp with the soil but also to keep down the weeds and grass, which otherwise take all the food of the fruit tree rootlets which means the health of the tree.

November.

Plough once again over sann hemp area.

December.

By December 25th remove soil round orange trees (adding this to banks on each bed), till small rootlets appear.

Mix 2 lbs. of slaked lime with fresh soil, and spread carefully all round and about tree, leaving a space immediately round the stem as in vines. Give 4 baskets for manure well mixed with soil to each tree. Cut away any twigs or branches that hang too close to the ground.

January.

January 1st.—Water orange trees copiously. After the soil is dry enough to be raked, remove soil immediately round trunk as directed for grapes and replace by mixture of fresh wood-ashes and earth.

January 20th.—Give each orange tree 7 lbs. decorticated cotton cake meal and 2 lbs. bonemeal using the same precaution as to not letting the manure touch the stem as in grapes.

January 30th.—Give each orange tree one basketful of fresh wood-ashes.

The sour limes (Indian Limbu) ought to be flowering and fruiting now.

Spray orange trees with weak solution of phenyle (1 part to 60 parts of water).

February.

The orange trees ought to be in bloom.

Give less water to flowering orange trees till fruits have set; then water copiously. Put 2 lbs. slaked lime round each orange tree, and mix well with the soil.

March.

Examine oranges for Mediterranean fly. Oranges affected will exude juice from tiny holes in the rind when pressed. Remove all affected fruits *and burn at once*.

Spray trees with Bordeaux mixture, or weak phenyle. Always spray *very early in the morning or in the evening*, see that vines and orange trees are well watered.

May.

See that orange trees are having enough water.

CONCLUSION.

From what I saw of the appearance of the orchard and the individual trees, I think Mrs. Tudor-Owen is to be congratulated for making such a successful attempt at the introduction of the Navel oranges. The system of pruning and manuring have been the secret of success. The cultivation is now beyond the experimental stage. It is obviously necessary, however, that the 'fruit fly' pest must be well controlled before recommending to cultivators.

The Sicilian lime and the Delhi oranges should be widely propagated and cultivated by the people.

CITRUS CULTIVATION AT JAMNAGAR.

During the course of the last two years Jamnagar is coming to the front in Kathiawar in the matter of orange cultivation. Before that time an orange fruit produced at Jamnagar was considered a novelty. There were many trees planted in the State gardens but none of them were known to yield fruit although old enough to bloom. The ordinary cultivator naturally cares more for irrigated crops such as brinjals, chillies, etc., that give immediate and early return of money invested rather than for fruit. Therefore nobody apparently knew or cared to give the necessary treatment for fruiting and the result was that the trees were considered a failure. Now the plants have been under the care of Mr. Mandke, the enthusiastic head of the State gardens at Jamnagar and an *alumnus* of the Poona Agricultural College, they are treated in the best possible way and their economic value ascertained.

During my recent visit to Jamnagar I investigated the possibility of the success of citrus fruits and the following is an account of the study. Mr. V. G. Mandke was good enough to show me all the gardens where different varieties were

planted. It must be mentioned here that these trees are to be seen only in the State gardens. They have not yet attracted the attention of local cultivators.

The following varieties were seen :—

(1) *Orange*, (2) *Mosambi*, (3) *Jamburi*, (4) *Galgal lime*, (5) *Id Nimbo*, (6) *Sakhar Limbo*, (7) *Sour lime*, (8) *Royal George Navel oranges*, (9) *Pomeloos*, (10) *Reshmi*, (11) *Godhadia type*, (12) *Small Naringi (Reshmi)*.

All these varieties are growing extremely well here. It is only a matter of few trials to see which of these are most economical in the end. Except No. 8 all have fruited already. "The Royal George" plants are still young and may take a couple of years before they reach maturity and declare their virtues. These trees differ from the Washington Navel Orange previously described as being cultivated at Palitana as the trees bear many stout thorns, while the Washington Navels do not have any. The produce of the most successfully treated varieties, namely *mosambis* and *santras* (oranges) were exported in November and December 1919 and June 1920 to almost all the States in Kathiawar and to such places outside as Bombay, Ahmedabad, Broach, etc. These fruits were derived from trees which are now six years old. The latter are now about eight feet high and ten feet through. They were treated for the *Ambebhar* last year, by digging, manuring, and irrigating the plantations at the times so well known to Deccan cultivators. The periods of preparatory treatment, however, vary to a small extent when compared with the Deccan, and it is to be noted that these periods are almost exactly one month later than those in the Deccan.

After the digging, etc., early in February each tree was given four baskets of farm-yard manure and 5 lbs. of bone-meal. The flowers appeared in March and April and the fruits are marketed from the middle of November to middle of January. I had no occasion to see or taste the fruits, but I am assured that they were much appreciated. I have myself

had occasion to meet with gentlemen in Junagad who spoke very highly of the recent Jamnagar oranges. In the last crop i.e., November and December 1919 and January 1920, the average number of fruits yielded by each *mosambi* tree was 162.5 and *santra* (orange) 223. The maximum yield of *mosambis* (in November, December 1918 and January 1919) was 200 per tree and the average was 70.6, while the maximum yield per *santra* orange tree in the same year was 449 and the average 135.6.

Sweet oranges are not usually cultivated in tracts close to the sea, but here the sea is within two miles of the orange garden, from which the fruits were derived.

The Kathiawar people seem to be very averse to eating anything acid however little it may be. They do not use common tamarind in their culinary preparation but they use *kokam* instead. Acid things are said to cause rheumatism. Therefore fruits having the small amount of acidity are discarded.

In Kathiawar *mosambis* fetch better price than *santras* (oranges). The local rates for *mosambis* are Rs. 1-4-0 to Rs. 1-8-0 per dozen, while *santras* (oranges) are 6 to 12 annas a dozen. The *santras* (oranges) are said to be equal to those of Poona in flavour, but the *mosambis* are sweeter.

Sour Limes (Kagdi limbus).—Some excellent specimens of these were seen. These plants thrive well and fruit abundantly. There is a good local market in Kathiawar where these fruits are used extensively for *athnu* (pickles). The yield from each individual tree has not yet been ascertained.

From a study of the general situation here it is impossible to deny the possibility of growing all citrus fruit plants. But I must forewarn the intending cultivators of Jamnagar and other places similarly situated not to fail to provide wind-breaks to the proposed fruit plantations. In a large area devoted to fruit regular lines of wind-breaks must be planted at distances of 200 feet to 250 feet. Plants further than

250 feet from a western wind-break are sure to suffer badly. Plants such as *Shevri* (*Sesbania Aegyptica*) *Inga dulchis* *Euphorbia tirucalli*, flourish well here and should be planted along with the fruit plants. In this tract hot and dry winds and even in some regions salt winds also begin to blow in the afternoons and early hours of the night from the middle of February and continue till the middle of June. A mango plantation suffering from the effects of wind was seen in Jamnagar. Three or four lines adjoining a western *sher* hedge had progressed well, while the trees further away were damaged in proportion to their distance from the hedge.

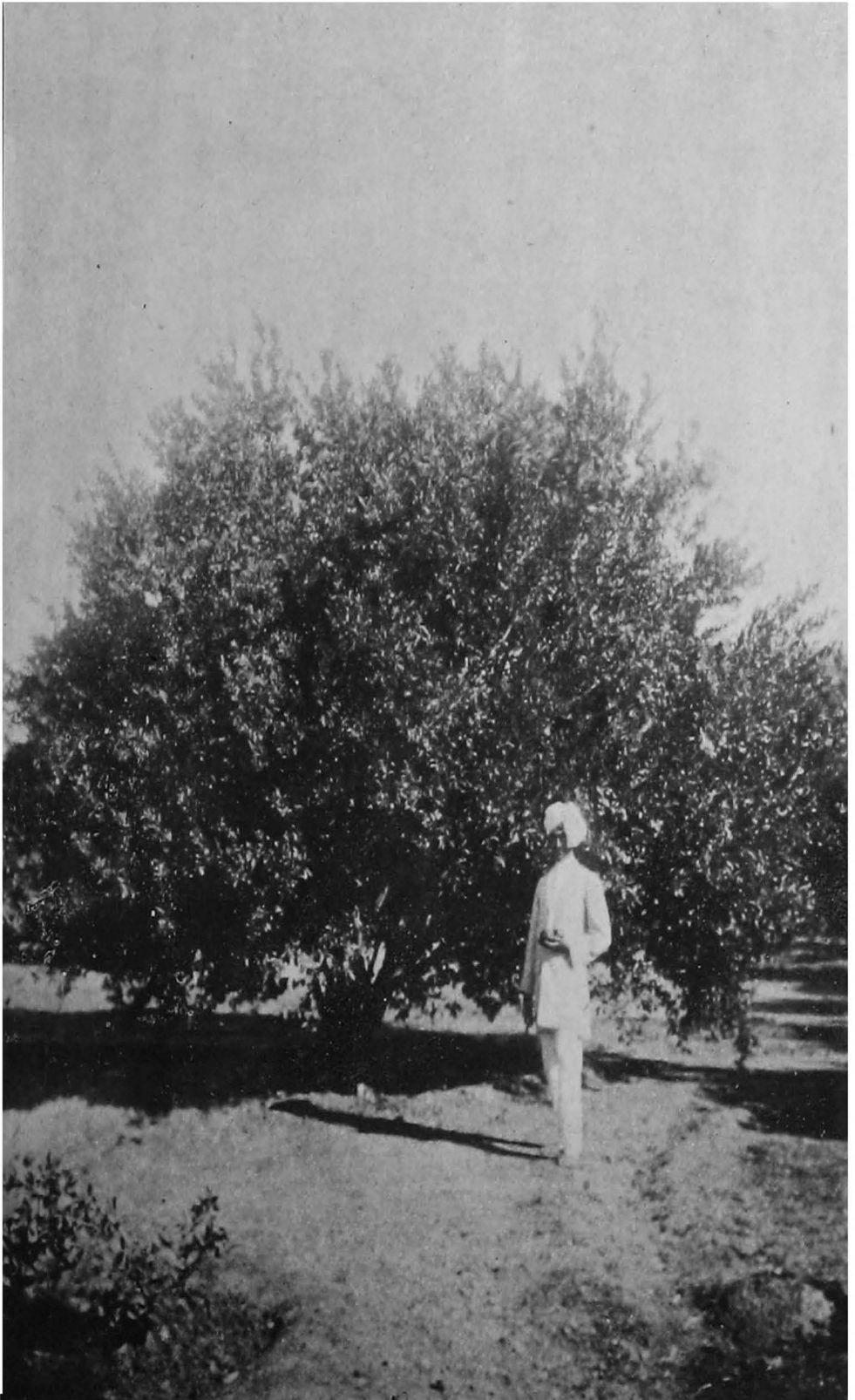
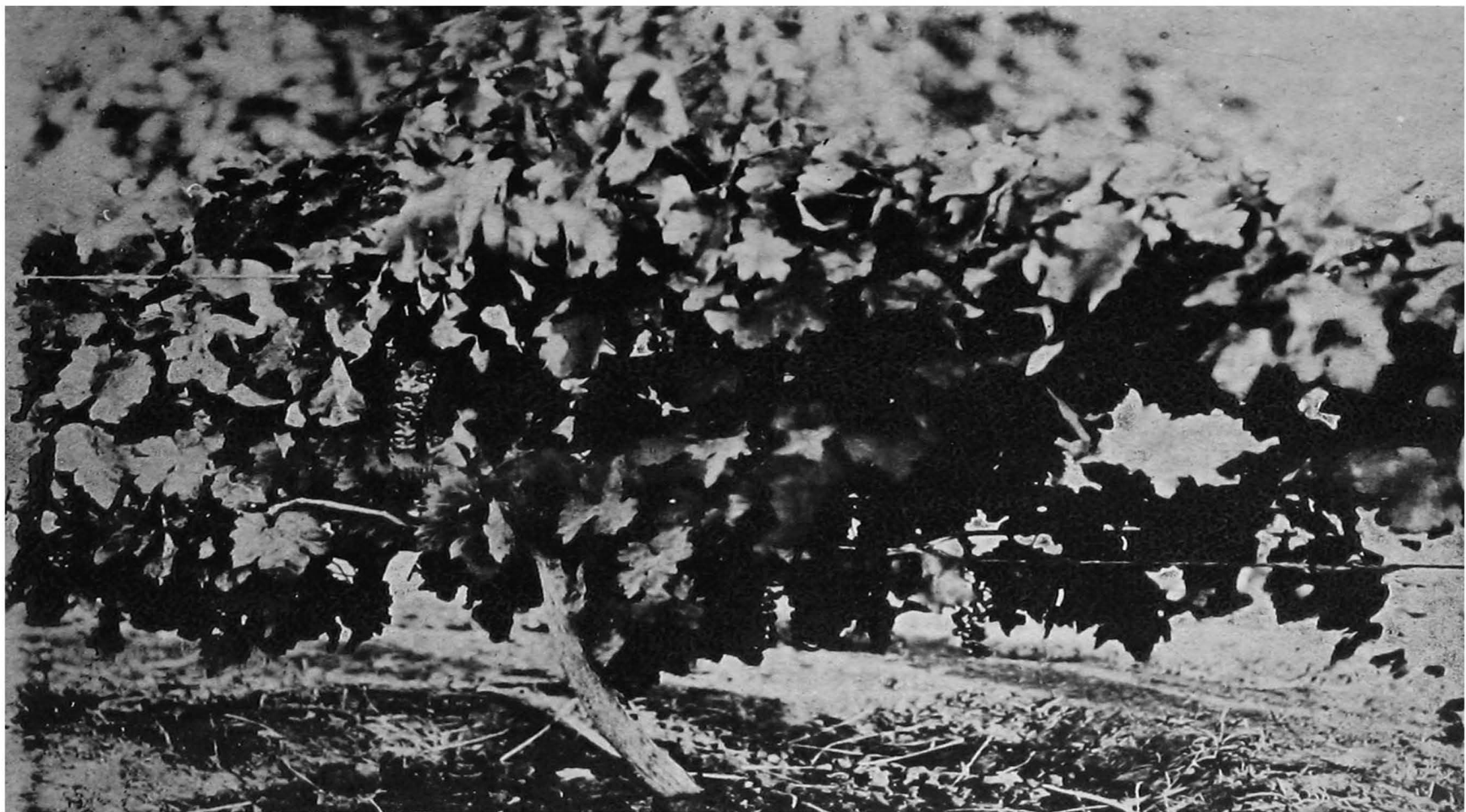
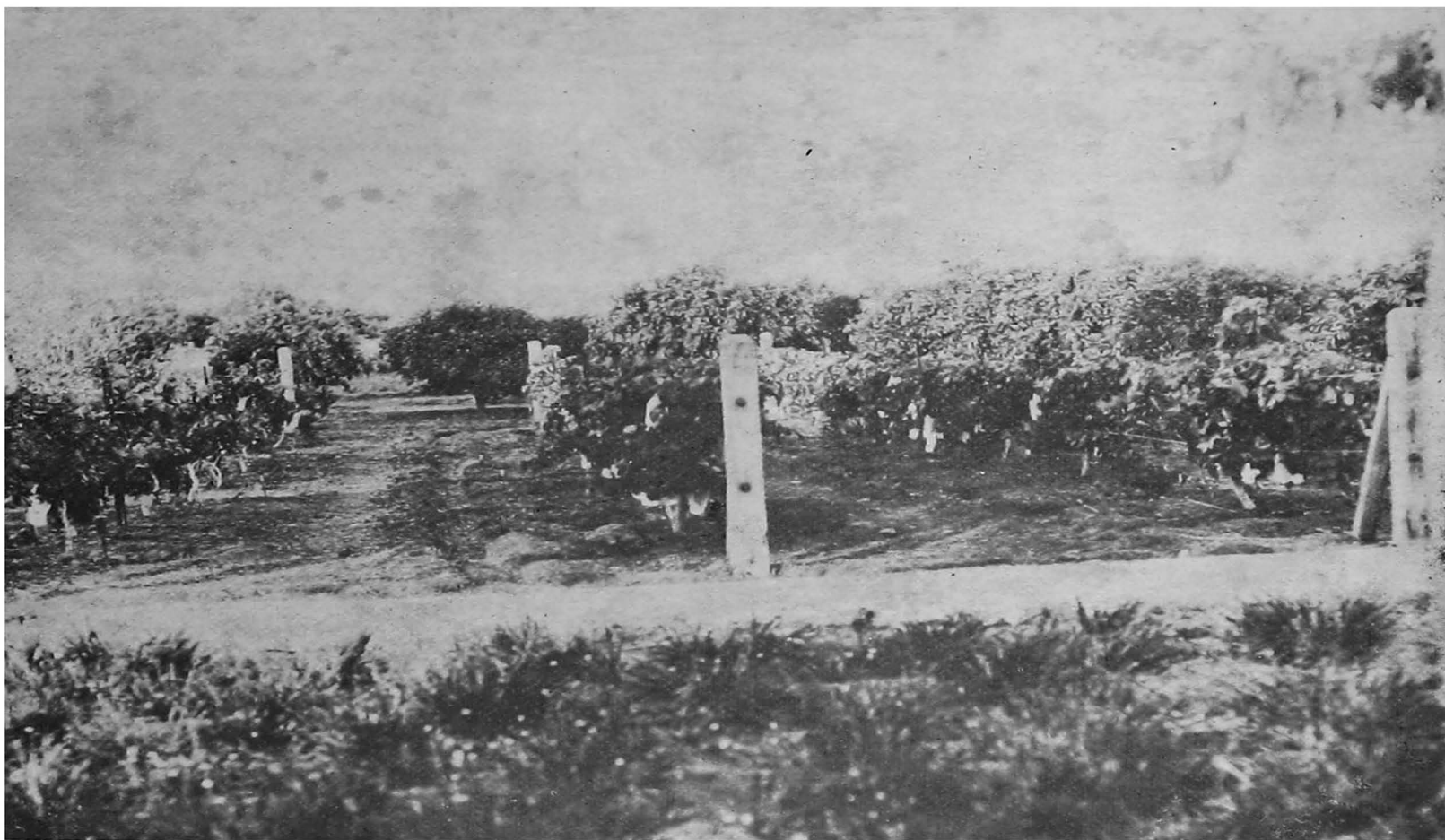


Photo of a specimen of a Delhi Orange Plant grown by Mrs. Tudor Owen in Hava Mahal, taken on 19th Feb. 1920. Palitana.



Reprint of a photo of a single vine plant in Hava Mahal taken in 1919. Palitana.



Reprint of the photo of the vine yard in Hava Mahal cultivated by Mrs. Tudor-Owen
in Palitana—taken in 1919.

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INDUSTRIAL SERIES NO. 1.

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PREFACE.

The Bulletin was written at the suggestion of Professor Patrick Geddes early in May, 1918, whilst the author was at Indore for the purpose of giving advice to the State on certain economic questions. Professor Geddes very kindly read the typescript and made several useful additions and alterations which have been adopted.

THE
NEW INDUSTRIAL TOWN
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The New view of Life and Work

This bulletin is written to explain the many new ideas which are connected with the establishment of an industrial suburb on the outskirts of the City of Indore. This event means the introduction to Indore of the new view of life and work,—that of Regional development and city renewal—in short of reconstruction—which has untold possibilities of benefit for all persons concerned. Very striking examples of the success of the new views are already to be seen in England and America. In the reconstruction in Europe after the war, already beginning, the principles to be outlined below, will increasingly predominate. Progress along these lines seems likely to be the chief characteristic of the twentieth century.

There are four great ideas at the bottom of the new view of life and work, namely:—(1) to obtain by *co-operation* in all sorts of forms numerous benefits which cannot be had by individual efforts, (2) to carefully *plan* all these joint or communal efforts so as to obtain the maximum utility, allowing for future needs as well as for present, (3) to study *efficiency*, that is the avoidance of waste, not only in railways and factories but in every branch of human activity both in work and life, (4) to *study human beings* in a scientific manner from the point of view of the efficiency of their work and the happiness of their lives. The application of these broad principles in the different spheres of work and life naturally involves many interesting but complicated ques-

tions which become themselves special subjects of study. Yet all of them are part of this new scheme of life and work; because they are directed in obedience to the above-named principles.

Co-operation

What is meant by *co-operation* and how is it to be secured? The word is used here in the broadest possible sense. Above all things is needed the *spirit* of co-operation—the desire to work with other people in order to reach jointly something definite, whether it be the improvement of the railway service, the laying out of a new street, or the passing of some reform of the laws. Special societies are often formed for special purposes. Joint stock companies are formed for all manner of business purposes. The citizens elect a Municipal Board to look after the sanitation of the city and its business. By loyal co-operation, in which all selfish interests are put on one side, the most remarkable improvements can be obtained. In a mill or commercial concern of any kind the object of the manager should be to stimulate in his work-people the sense of co-operation, so that they help each other to the fullest extent, and co-operate with the management instead of merely submitting to orders.

Planning

The second great idea is the careful planning of everything with the proper forethought. It is the usual custom to plan out a house in all its detail before starting to build it, because experience has shown the immense advantages of so doing. A house to which a room is added here and another there, as the family grows in size, may be picturesque, but it can never be so convenient as a house which is properly planned out in advance. But there is a great deal of difference between a good plan and a bad plan of a house. I have seen a house in the plan of which the builder forgot the staircase, and it had to be put in afterwards by cutting off a large part of the best sitting

room, and was even then a very bad steep staircase. Other houses are badly planned simply because the rooms open on the wrong side, so that people have to walk quite an unnecessary distance about the house every day of their lives.

A more intricate case of planning than a dwelling house is the laying out of a cotton mill or factory. In this case the problem is how to arrange the different departments containing the machinery for successive stages of the manufacture in relation to one another and to the godowns in such a way as to reduce the carrying of the material and the distance for transmitting power and steam to the minimum. If material in process of manufacture is constantly being carried backwards and forwards across the compound, or from one end of a building to the other, a great deal of money is wasted, for the expense of moving the material about is all added onto the cost of production. In England and America it is now recognised that no great mill or engineering works can hope to be a profitable concern unless the utmost attention has been given beforehand to laying out the whole of it, so as to reduce all costs of moving goods and transmitting power and heat to the minimum. There are a few examples of good industrial planning in India such as some of the big new jute mills in Calcutta, and the Tata Iron and Steel works.

It may be observed that the planning of any industrial concern must be external as well as internal. It should be arranged so that a railway siding may be brought into the compound, with direct access to a public road for the work-people to come and go by the shortest distance from their home (and sometimes the access to water is of great importance.)

A more important and yet more difficult art is the planning of cities, which are themselves both the homes and the work-places of thousands of people. The well-planned city, just like a good house, must meet the needs of the

housewife going to the bazar to purchase the daily necessities of life, and it must give the proper provision for the schools and the play-grounds of the children and opportunities for the recreation of the adults. The external surroundings should be as pleasant for the poor as they now are for those of the wealthy who can afford to keep big gardens. But the city is also the place of work; and as such there is enormous waste in every direction in the transport of materials to the work-shops and factories and in delivering goods to the shops. I venture to say that in the city of Indore at least one thousand rupees a day is being wasted from this cause alone, which would be saved if the whole city could be planned out and rebuilt from the beginning. This, of course is impossible; but without in any way destroying the existing city it would be possible by making a few new roads and railway sidings to save half of this waste.

Yet another and greater sphere for efficient planning is open to us. The city is dependent for the raw materials of its manufacture upon all the country surrounding it. The railways and the trunk roads are the great arteries by which the produce of cultivation goes to the cities to be consumed, and by which the manufactures of the cities go out to the villages. The cost of such transport is at present enormous, totally preventing much trade which would otherwise come into existence between the city of Indore and the outlying portions of the State. Here then, is a great opening for planning upon a comprehensive scale so that the cost of transport from every village to the nearest railway station, or direct by road to Indore, shall be cut down to a figure which makes it worth while for the cultivators to grow commercial crops and profit by them.

Efficiency

Another great principle of the new view of life and work is to study how to secure Efficiency in every possible direction. Efficiency simply means how to get the most

out of anything with the least possible cost in effort or money. When measured in money it means the same thing as economy or the avoidance of waste. The idea applies in every direction of life, but it is best understood in engineering; for example, the efficiency of an engine means how many horse-power-hours are obtained out of every maund of coal consumed. The efficiency of the engine of a motor-car is measured for any given size of car by the number of miles that can be run per gallon of petrol. The efforts of all inventors and designers of new machinery are devoted to securing greater efficiency of their machines. A colossal amount of hard thinking and of money has been expended on experiments made with every kind of machinery to increase its efficiency by improving the quality or quantity of its output, or reducing the running costs in power or labor, or in reducing the wear and tear of its parts.

It is also possible to secure much greater efficiency in the running of any machinery by the work-people who have to attend it. If a power-loom is stopped, say, for a quarter of the length of the working day, on account of broken threads, it is obvious that any system of working which reduces the idle time of the loom to one-eighth of the working day will increase the output by 25 per cent. In other words its efficiency is increased 25 per cent.

But it is not only in the use of machinery that increased efficiency of work can be obtained. The new "Scientific Management" introduced ten years ago in America is directed towards securing greater efficiency in every kind of productive work. Not only do the machines produce twice as much when the right workman is found and trained to the machine, and the machine is adjusted to the capacity of the workman or woman; but in operations done entirely by hand, or with a few simple tools, the most surprising increase of efficiency can be obtained by a proper scientific study of the movements which the worker has to make. To illustrate this let me take the case of laying

bricks to build any kind of wall for any large building or house. By what is called "motion study" an American engineer and contractor, Mr. Gilbreth, who, as a boy, was brought up as a brick-layer, has secured an enormous increase of efficiency in this apparently simple art of laying bricks. Under the influence of Mr. F. W. Taylor, who has done so much to popularise scientific management, Mr. Gilbreth determined to study the process of laying bricks, to see whether it was possible to make improvements in it. "At first sight the undertaking seemed presumptuous. Bricklaying is one of the oldest of the crafts, having a history dating from Babylon and Nineveh. For several hundred years no noteworthy improvement in processes had been made. Mr. Gilbreth, however, made persistent observations of the most detailed character, disentangling the processes into the elementary movements composing them, and observing the position and character of the apparatus and supplies and finished work which determined the efficiency of each movement.

"The traditional method of laying bricks is familiar to every one. Mr. Gilbreth found tenders bringing up thick mortar and unselected brick to the scaffolding, and dumping them at the feet of the masons. The scaffolding was raised only at intervals, when further reaching was impossible, and was then put up even with the wall. He found the masons reaching and stepping and stooping to get mortar and brick, often pausing to work up the mortar or select the best face of a brick. On the wall the mortar was spread and cut off, the ends of the brick were buttered and the brick was tapped into position with the handle of the trowel. The mortar squeezed out by the tapping was then cut off and disposed on the wall or the board. In this way there was completed a cycle of operations containing eighteen elements.

"Mr. Gilbreth soon began to introduce changes. One of the first things done was to devise a new scaffolding. This was planned to include, first, a lower platform consisting

of a front portion next the wall, on which the mason stands, and a rear part, away from the wall, along which the tender walks. A second platform consists of a shelf upon which the mortar and brick are disposed conveniently to the hand of the mason. The front of the material shelf is seventeen inches from the line of the wall, thus eliminating all stooping and stepping for supplies on the part of the mason. The scaffolding was so constructed that it could be raised by the tender, a few inches at a time.

“ The order in which the brick should be placed in the wall was next studied. A sequence was worked out for each type of wall, involving the least total travel in laying up a given number of courses. To save the time used by the mason in picking out sound bricks and selecting the best face, low-priced helpers were employed to do this work on the ground; the bricks being sent to the mason, and sometimes to the job, in packets of twenty-four selected bricks, each brick having the best face up. To avoid loss of time with the mortar, a box was devised with sloping sides so that the mason might insert the trowel without looking, while his eyes followed the other hand to the brick packet. Strict control of the consistency of the mortar was instituted so that a brick could be pushed into its place on the wall without tapping, and without cutting off extra mortar.

“ By means of such improvements this ancient craft has been completely changed. Of the eighteen processes previously performed by the mason, ten have been eliminated, one has been arranged to appear only in every other cycle, three have been combined with other elements, and two have been improved. The apparatus has all been redesigned—even a fountain trowel being invented; the materials have been standardized in quality and located at the most convenient points; the most economical movements and sequences of movements have been adopted; and a rational division of labor has been worked out between mason and

helper. As a result of these changes, a mason can now lay 350 bricks per hour with no more fatigue than the laying of 120 bricks per hour would have entailed under the old system." *

Study of Human Beings

The fourth great idea of the new view of life and work mentioned above is the study of human beings in a scientific manner, with a view to increasing not only the efficiency of their work, but also the happiness of their lives. This is really the extension of the idea of motion study to the whole life of man. It is not only the bodily motions of the worker at his work which require to be studied and improved. It is possible to increase his efficiency as a worker in a great number of other ways. For every man or woman who is in regular employment, his or her work is an essential part of life. It is impossible to separate a working mechanism from the person as a whole; and this explains the well-known fact that the occupation influences and even changes the whole character of a person, sometimes improving him, sometimes degrading him, according to the nature of the work. Some kinds of work have an educative effect, and some have a beneficial effect, on those engaged on them, the educative effect calling out qualities of inventiveness, energy, courage, and resourcefulness. Other kinds of work are so monotonous or deadening to the faculties that people are driven to unwholesome excitements and to drink or drugs.

The conditions under which the work is done also have a great influence on the worker, as well as the character of the work. If the hours of work are too long, so that nervous fatigue is experienced daily, the worker does not lead a normally healthy life. He has no leisure time; or in the little he has he is too tired to do anything to benefit himself

* This quotation is taken from a book entitled *The Administration of Industrial Enterprises*, by Edward D. Jones, Ph. D., Professor Commerce and Industry in the University of Michigan. (Loringmans, Green & Co 1916).

or to be useful to the community. It has been found by experience that the reduction of the working day to eight hours, and in some industries to seven hours, has so increased the efficiency of the workers that the combined output of the workshop or factory was actually increased. One over-tired workman is often a weak link in a chain, and his inefficiency keeps back the other workers.

There are many other conditions which greatly increase the efficiency of labor, because they assist the workers to be healthy and happy. All the working rooms should be very light, high and airy, good ventilation being obtained by electric exhaust fans, if necessary.* The temperature should be neither too hot nor too cold. Many Cotton Mills find it a great advantage to cool the air in summer and warm it in winter; and this practice would be very advantageous in a climate such as that of Indore. It is impossible to describe in a few words all the ways by which the efficiency of the workers can be improved by taking adequate thought for the welfare of the work-people. The reader of this is recommended to obtain a very noteworthy book called "An Experiment in Industrial Organisation" by Edward Cadbury, † which describes in detail how the great cocoa and chocolate factory at Bourneville near Birmingham is managed. There are 6,000 persons employed in the works, and the bodily health and conditions of life and work of every one of them are studied and controlled in detail for their benefit; and thus also indirectly for the benefit of the factory owners, because they both together have abundantly proved that happy healthy workers are the best workers and produce the most profit. It is not to be supposed that Mr. Cadbury undertook the betterment of the conditions of his work-people with a view to profit. He regarded it as a matter of duty, both

* It is worth noting that the very enlightened and enterprising proprietor of the Indian Press, Allahabad, Mr. Ghosh, acted on these principles several years ago. The rooms are very well lighted and there is no crowding of the workmen, who are kept cool and fresh during the hot weather by mechanically driven punkahs in all the rooms.

† Published by Messrs. Longmans, Green & Co.

religious and social; and he spent great sums of money on building houses in a Garden Village where his work-people could live and have their own little gardens and recreation grounds and everything that makes life healthy and pleasant. He had sufficient sympathy with his work-people to wish that they should not be ill and go without proper medical attendance. Consequently he employed a doctor for the factory to look after everyone free of charge.

In course of time it appeared that this beneficial treatment was also good business policy; and this led to the organisation of the human element of the great factory upon a more perfect business footing, as well as a more rational basis of human effort. It was made a rule that one of the staff of factory doctors, must examine every person before he or she should be employed, and that every person working in the factory must be examined by the doctors at regular intervals of two or three months. Dentists were employed to put the teeth of the work-people right entirely free of cost to them, thereby very largely reducing loss of time through pain, and from diseases due to indigestion. Most interesting and successful experiments were also made in insisting that all employees have a sufficient amount of physical exercise to keep them in good health. Educational facilities of all kinds were offered; some of them directly connected with the various trades carried on in the factory itself, but others simply cultural. Experiments were also successfully made in associating the more intelligent workmen with the management; so that their suggestions might be taken advantage of and their assistance be utilized in committees for the regulation of work and the immediate settlement of those petty disputes and grievances which often ultimately lead to strikes by their cumulative effect. These principles are now being adopted in many other big factories in England and America; and their general adoption would mean an extraordinary increase in the working capacity of the whole population.

Municipal Efficiency

Such reforms deeply affecting the life of the industrial section of the population cannot but have a very beneficial effect upon the life and health of the whole city population. The industrial workers are a not inconsiderable proportion of the whole, and their better mode of living will set up a new standard for the people of the city, represented by their Municipal Board and its officers. The members of the Board are the guardians of the health and happiness of the people in the city. It is for them to study the needs of the inhabitants—in fact to carry out a scientific study of human beings from the point of view of the public facilities for life and health. They will not only look after the drains, and the removal of the refuse; they will also see that people are not obliged to live in over-crowded conditions. They will also see that there are plenty of recreation-grounds and gardens. They will provide a sufficient number of schools of various kinds, and one or more public libraries. If they are wise they will see that all new houses whether built for the wealthy or for the working classes are carried out on rational lines conducive to health and well being. This does not mean much extra expense. It means simply reserving a sufficient amount of land to give everybody some garden, and the laying out of suburbs for the poorer classes on garden city lines. In this and many other ways the State Government and the Municipalities can help to increase the health and happiness of the people.

Plans for Indore

The general principles of the new view of life and work have now been sketched in outline. It will be possible, therefore, for the reader to form an intelligent appreciation of the plans which have already been begun for the improvement of Indore and to understand how further progress can be made. He will see what enormous opportunities there are for improving the working capacity of the laboring population both in the mills and the factories and in

the smaller workshops scattered throughout the city. He will see that Indore, if it works by these principles, may rapidly become a much greater, healthier, happier and wealthier city. Surely there is no greater enterprise which the people of any city could undertake.

Industrial Town

The first step towards realising the ideals described above has already been taken by the commencement of laying out the new industrial town of Naya Indore, on the north-east side of the city across the railway. The new industrial town begins where the Hukum Chand and United Malwa Mills stand, and it extends beyond the Brush Factory and the Malwa Mill in a north-easterly direction. This area was selected some years ago as suitable for the erection of the mills and fortunately it has proved to have been a happy choice, for Prof. Patrick Geddes who was called in by His Highness to report upon the town-planning of the existing city, and to provide plans for its extension, regards the choice as the best which could have been made. He has devised a very suitable and practical plan for the unlimited growth of this new industrial town, providing sites for another twenty mills or factories, and allowing yet more land to be taken into the industrial town whenever required.

The existing mills and factories in Indore are working under a handicap, from the fact that they have not got sidings from the railway going straight into their compounds. It is well known that a very great saving is possible in the cost of carting the raw materials to a factory and the finished goods away from it. If a siding is provided so as to run right along side the factory godown, bales of cotton or other materials are then unloaded direct from the wagons into the godowns, and the expense of transferring into carts is entirely avoided. Plans have been prepared for providing the existing mills with sidings at a very early date; and the plan of the new industrial town shows a circular arterial siding which throws off two main branches to the north.

By this plan there will be railway lines at one side of every new factory site and it will be a simple matter to bring a branch for each mill or factory right into its compound.

There are many other ways besides the provision of sidings by which mills to be erected in the future can be made more efficient than the older mills. Very important is the provision of cheaper power, preferably by means of electricity. The water resources of the State for hydro-electric schemes are under investigation; but should the water power available not prove sufficient for the probable requirements of the rapidly expanding industrial city, it is proposed to establish a central steam electric generating station so arranged that it may ultimately be fitted with machinery capable of producing all the power required. This generating station would be situated probably at the further end of the Industrial Town from the city of Indore so that the smoke would be carried away from the city; and it would provide power for all the mills in the city existing now or to be built hereafter. Very great economies in consumption can be effected in such a large generating station; so that mills would get their power cheaper than they can now with burning coal under their own boilers, and the residents of the city would have the great advantage of the air being free from contamination by smoke.

Sites will be provided also for industries auxilliary to the principal mills and factories. There will be brick and tile works, and engineers' work-shops and a foundry, and possibly a power-driven saw-mill and joinery plant.

Books on Planning and Management

On a foregoing page reference was made to the very great importance of the careful planning of mills and factories before they are erected, so as to secure the most economical working. The Minister of Commerce and Industry having this in mind is taking steps to procure from Europe and America all the technical books and publications especially

relating to the planning of mills, works and factories, and to the business organisation of such undertakings, including efficiency and welfare management. Persons intending to start new industrial enterprises in Indore are recommended to consult these books, which may be borrowed free of charge from the library of the Department of Commerce and Industry.

Housing of Work People

Professor Geddes has made excellent provision for the housing of the work-people in the new industrial town. The old fashioned idea was to have each mill build some chawls or "cooly lines" in its own compound, sometimes surrounded by a high wall. There are a great many objections to this practice, and it should certainly not be permitted in Indore. The modern town planning practice is to prohibit the residence of employees in the compounds of factories, excepting so many as are actually required to be constantly present, as engineers, firemen and watchmen. Land is specially reserved in the near neighbourhood of the factory sites for the purpose of erecting the workmen's dwellings, and a limit is set to the number which may be built per acre. Where land is cheap, as it certainly is in Indore, it is possible to build the workmen's dwellings on garden city principles. I am glad to know that this has been recommended by Prof. Geddes, and to find that his plans, which I have carefully inspected, have been drawn in such a manner as to give the work-people every condition for a healthy and happy life. I have every hope that this will lead to the growth in Naya Indore of a permanent working class population. The people should be given leisure to cultivate the gardens which will be given them, and the planning of trees will be encouraged. Sites will be provided for several elementary schools, for a technical school and for bioscope theatres, and other legitimate places of recreation. Professor Geddes is proposing to make picturesque use of the nullas which cross the area of the new town, retaining the water with bunds, and laying out pleasant public gardens and ghats on the banks.

Efficiency Management

Without doubt there is an opening for the introduction of improved methods of scientific management in all the industrial establishments of Indore. The introduction of systems of cost accounts, of defining jobs, and measuring the efficiency of work of each individual worker, so that the slack workers may be stimulated and taught how to improve, or if found unteachable may be dismissed—all these require special study on the part of the managers themselves, or of officers specially appointed to work under them. The State cannot do more than call the attention of owners and managers of industrial concerns to the very great progress which is being made in other countries by attention to these matters, and by putting within their easy reach up-to-date literature describing the methods which may be adopted and the results which have been actually achieved elsewhere.

Welfare Management

Here again the State desires to call the attention of employers of labor to the measures which it would be wise to undertake for the benefit of their work-people. Shorter working hours will prevent the lowering of efficiency of work due to over-fatigue; which predisposes the work-people to ill-health, and makes them susceptible to epidemic diseases. The long working hours of labor in India, together with the very unpleasant housing accommodation available, are largely responsible for the frequency with which the workers return to their villages. Experiments might be made in working in two shifts in the mills, because it is notorious that the Indian workman of the cultivator class, after he has made sure of a very moderate income, greatly prefers increased leisure to additional earnings. This question involves providing housing accommodation for additional workers.

There are many other ways in which the welfare of work-people may be promoted, and with advantage to all concerned. The application of the principles outlined in the

foregoing pages regarding the scientific study of work and the workers will, in the course of a few years, yield astonishing results in increased efficiency, both in quality and quantity of output, if the matter be energetically taken up. In this respect the Commerce and Industry Department will at all times be ready to offer such information and assistance as may be in its power to give.

REPORT OF THE SURVEY
OF THE
Wholesale Markets of Indore City.

PREPARED FOR

The Minister of Commerce & Industries
HOLKAR STATE

BY

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INTRODUCTION.

In December, 1918, I was asked by the Minister of Commerce and Industry in Indore State, to undertake a survey of the wholesale markets of the City of Indore with a view to the improvement and the betterment of these markets. The report herewith submitted embraces the following markets: Lumber; Brass and Copper; Leather; Cotton; Cloth; Iron and Hardware; Grain and provisions. Gold and Silver, Market, and the Cotton Exchange.

The facts in reference to each of these markets have been derived from various sources. In so far as possible official figures have been used; and for some purposes recourse has been had to the Transit and Transport passes themselves. Much of the necessary material, however, cannot be secured from official records. It is known only to the merchants themselves; and considerable time has been spent in conversation with the leaders of each branch of commerce, and with others whose duties have made them familiar with the conditions of the markets.

I have been faced with several difficulties. A survey of this nature involves the training of investigators, and that training can only take place actually in the markets. Much of the success of such an investigator depends upon his method of approach to the merchants, and his ability in overcoming suspicions naturally raised when questions in regard to their business are asked. I have been fortunate in finding three men who have ultimately been able to do this with considerable success: Mr. B. S. Apte, B. A.; Mr. K. A. Kelkar and Mr. Radhakrishna both of the fourth year class of the Indore Christian College. In the securing of official records there have been certain difficulties, due mainly to lack of interest in the investigation and to continued pressure of the daily work in the offices upon the clerks. Many of the old records do not appear to have been totalled; and records such as those of the transit and transport passes coming into Indore have never been made up. For some records I have been compelled finally to send my own workers, who, naturally, have been greatly handicapped by their lack of knowledge of the system. The most willing and rapid assistance has come throughout from the Muntazim Sayar's Office.

The location of the several markets is indicated on the accompanying map, together with the position of the various nakas in the city.

PART I.

CHAPTER I.

The wholesale Markets of Indore City.

General:—Indore is the capital city of Indore State, one of the largest of the Native States of Central India. It is situated on the fertile Malwa plateau, but its historic development has associated it closely with the north bank of the Nurbadda valley. It is midway between Khandwa and Rutlam upon the metre gauge Rajputana-Malwa Railway; now operated by the B. B. & C. I. Railway, and it is 482 miles distant from Bombay. It is the focus of a well built system of roads which connect it with all the surrounding States and important towns.

The commerce of Indore is carried on in three main divisions of the city:—Indore city proper; Shiaganj; and Indore Residency. The first two are directly under the authority of the Indore Durbar; the latter is British territory on which are located the administrative offices and the residence of the Agent to the Governor General for Central India. In the Residency the traditional British policy of free trade has been followed, and considerable commercial development has resulted, as accompanying figures will show. Merchants are subject, however to a trade tax at the rate of $2\frac{1}{2}$ per cent on the annual income or profits derived by each assessee from his profession, trade or dealing. A "Beyai Tax", which came into force first in 1895, is levied at the rate of $\frac{1}{4}$ per cent ad valorem on all sales to the value of Rs. 25 and upwards made within the Indore Residency Bazar on scheduled articles after importation into the Residency Bazars. It is levied on an article as often as it changes hands within bazar limits.

In Indore City proper, as throughout Indore State, merchants are subjected to a 'customs tariff' upon certain scheduled articles, including certain articles of export. In 1891 a Report, (No. 103/17-2-1891) was submitted by the Sayar Department to the General Department in which it was pointed out that because of the Sayar duty on goods imported by the traders of Indore City as well as because of the high ground rent in the city, the merchants were taking their goods to the Residency. In view of this the district known as Shiaganj—lying between the railway track, the river and the road back of the hospital compound to its connection with Shiaganj road at the Sayar Office and the Kanipura Naka—was declared a free zone. In it arrangements were made to levy municipal taxes upon the rent of buildings; but the district is exempt from all Sayar taxes on imports and exports of goods. Shiaganj was thus brought into direct competition with the Residency markets. Its development has been rapid, and—with the exception of the cloth, gold and silver, and part of the iron markets—the large import markets of the city are now found within its narrow borders.

In 1898 an arrangement was made between the Indore Durbar and the British Government by which the Durbar removed all nakas surrounding the Residency area and other hindrances to the trade of the Residency. In return the Residency pay to the Durbar annually two thirds of the net income from the Garri-Adda in the Bazar, and from the Beyai tax.

In order to facilitate the work of the nakedars at the boundary nakas of the State, a system of "transport" and 'transit' passes is in operation. "Transport" passes are issued for all goods sent by cart by one merchant in the State to another merchant in the State. 'Transit' passes are issued for all goods passing through the State by cart from one foreign territory to another. Indore Residency and Shiaganj, for sayar purposes are both foreign territory.

The relative strength of the three markets may be judged from the following, statistics of transport and transit passes in 1916-17 and 1917-18:—

(Transit and Transport Trade)

	1916-17	1917-18
Transport Passes from Indore to Indore State	3,751	6,148.
Transit Passes from Shiaganj and Residency to surrounding States	6,735	9,723.

An analysis of the transit passes for the months of November and December, 1916,—in which the number of passes equalled the average for the year,—shows that the quantities of the important articles exported by pass were as follows:—

	Shiaganj.	Camp.
Rice	1,667 bags	445 bags
Sugar	2,053 „	596 „
Kirana	9,133 bundles	2845 bundles
Kerosine... ..	5,749 tins	2046 tins
Ghee	763 „	196 „
Cattle	2,213	

During the same period the value of the articles sent out by merchants in the City to Indore State totalled as follows:—

	Rs.
Cloth	92,288
Metal	24,423
Kirana	225
Cattle (number)	156
Gold and Silver ...	21,254
Yarn	3,827
Shoes	2,132

These figures indicate with clearness the nature of the markets of the city and of the foreign territories surrounding it. During 1916-17 the number of passes issued for goods in transit into Shiaganj and the Residency totalled 1,508,—a little over half the number of transport passes issued in that year from all of Indore State for goods coming from the State into the city markets. It is apparent that if the business of the Residency and Shia-

ganj were confined only to the transit trade with surrounding States,— which, of course, it is not,—it would bulk very large in the total trade of the city.

The relative importance of Indore in the markets of the State is clearly indicated by the following figures of imports into and exports from Indore city and from all the nakas in Indore District in the year 1917-18:—

Imports.

	<i>Indore City.</i>	<i>Indora District.</i>
Rice (mds)	38,366 ...	... 3043
Sugar, Indian (mds).	22,416 ...	... 1528
Sugar, Maur (mds)...	19,270 ...	... 2289
Ghee (mds)	5,519 ...	... 357
	Rs.	Rs.
New Metal (value)...	1,89,434 ...	... 22,073
Old Metal „ ...	1,01,455 ...	... 14,523
Cloth, Foreign „	33,15,417 ...	2,87,881
Gold „ ...	10,492 ...	21!
Silver „ . . .	1,23,400 ...	12,725

Exports.

Hides, small ...	29,519 ...	1,772
Cotton, cleaned (mds)	4,945 ...	102
„ pressed „	11,944 ...	0
Tobacco (value)	Rs. 55,994	Rs. 75,029

CHAPTER II.

The Lumber Market.

Location:—There are two markets for lumber; but the main market, in which what wholesale business there is is carried on, is in Juna Pittia, about a furlong from Khajuri Bazar.

The Merchants:—The trade at present is in the hands of thirteen Mohammedans, whose families originated as follows: four in Indore, four in Mhow, and five in Dhar. With two exceptions—one a recent arrival from Mhow, and the other a resident for forty years—all have lived here since birth. Three new shops have been opened within

the past nine years. One merchant, the largest, has a large business also in Shiaganj where the better class of woods is sold; but the activities of the others are confined wholly to the lumber trade in the city.

The Trade:—Both wholesale and retail trade are carried on in the market by all the merchants, the latter very much predominating. More than seventy per cent of the demand comes from Indore city, more especially from the banias and other big merchants. Sales to outside villages are irregular and small, and then only to the banias or large landowners. The woods dealt in are as follows:—Sagon; Anjan Kaliya—for pillars; Sadar,—for carts but not for wheels; Temlesi—for roof trees; Khair,—especially for ploughs; Dhawada,—for ploughs, and also for roofing; Alinus,—for guitar and musical instruments and for sticks; Bamboo; Sisam; Mahuwa; Halon; Timach; Rohan; Kulam.

The annual business of the market amounts to almost a lakh of rupees. Of this one merchant does about one quarter. Two others do over Rs. 10,000 each; five do over Rs. 5,000 each; and five do under Rs. 5,000 each.

The timber comes principally from the following places:—

1. Indore State
 - Choral
 - Nimarkheri
 - Kannod
2. Betul District.
 - Dhodra Mohar
 - Kala Akhar
 - Ghora Dongri
3. Hoshangabad District.
 - Itarsi
 - Sohagpur
 - Pipariya Posar
 - Timarni

4. Jubbulpore District
Bahai
Narsingpur.
5. Khandwa.
6. Bombay.

The effect of the war was most marked upon the market in 1915-16; and increasingly higher costs of transportation are reflected in the decrease of importation of timber of the second class, and in the increase of timber of the first class. The following figures of importation from outside the State—which is entirely by rail—are illustrative:—

Year	First class (bullock garis.)	Second class (bullock garis.)
1910-11	1453	1274
1913-14	3528	1644
1915-16	1601	843
1917-18	2263	747

Finance:—The merchants finance their business partly by personal capital; but they borrow considerably from the banias or bankers at Rs. 1 to Rs. 1 as. 8 per cent per month. Only three or four of the merchants do not borrow. Others say that, although they might ordinarily finance their business by themselves, nevertheless they will borrow some occasionally from the bankers so as to maintain credit with them. thus they can get capital when they urgently need it.

Improvements desired by the merchants.

1. A reduction in the cost of transportation.
2. More capital readily available;
 - (a) The trade flourishes better when it is on a large scale.
 - (b) The trade is of a costly nature owing to the necessity of each merchant keeping all kinds of wood in stock in order to keep his trade.

3. Proper store houses for woods for the rainy season. At present, it is said, there is considerable loss through the action of water and dampness owing to insufficient protection.

CHAPTER III.

The Brass & Copper Market.

Location:—The market is located in Kasera Bazar, to the south of the Old Palace, and west of the cloth market. Workshops are also on the outskirts of the city near the entrance of the Dhar road.

The Merchants:—In the market there are six wholesale dealers, and from thirty to thirty-five retailers. In the workshops the workmen number about 300.

The Market.—The total trade amounts to between seven and eight lakhs in a normal year. This is about double the volume of trade fifteen years ago.

(a) Sources of Supply.

1. Much of the necessary pottery work is done in Indore. The big merchants bring brass and copper sheets from Bombay, and manufacture here dishes, water gharas, polis, kadhais, and broad bottomed vessels. There is a large workshop on Harsiddi Road employing 40 men. The manager, says that he intends to bring machinery from Bombay and develop the industry on a large scale.

2. Poona: dishes and katries.

3. Nasik: vessels and a particular type of lota.

4. Mirzapur: cups and lotas of a particular type.

5. Delhi, Rawalpindi, Ajmere, Calcutta, Benares, Sehore (Kathiawar), Rewari, Agra, Cawnpore, Surat and Ahmedabad for brass idols.

(b) The Sale Market.

1. The main market is in Indore itself for the sale of articles. Mainly through the annual fairs, however, a considerable trade is carried on with the villages of Indore, Dhar and Dewas. This, of course, is chiefly a retail trade.

2. Some manufactured goods are shipped by rail as far as Nagpur, Jubbulpore, Gwalior, Jaora, and Sawai Madhopur.

3. A very considerable trade is done in old and worn brass and copper, to some extent with all the places from which articles are imported, but more particularly with Mirzapur, Bombay, Ajmere, Poona and Nasik.

Improvements suggested by the Merchants.

1. It is suggested that a brass factory be developed here by the State with the assistance of the large dealers. It is pointed out that skilled workers are available in Rampura district. They could be brought here.

2. Assistance is necessary to secure the large amount of fuel consumed. It is suggested that favored rates might be given by the municipality.

CHAPTER IV.
The Cotton Market.

Location:—The Cotton Exchange is in the Big Sarafa. It is composed mostly of speculators, and appears to have but little connection with the cotton produce market of the city. Buying and selling of actual cotton takes place either in the city or at the municipal godown for cotton, situated opposite the railway freight godown. In this godown all cotton coming into Indore is stored; and there the majority of the bona fide transactions take place. The chief participants are the mills and the Shiaganj merchants.

The trade:—The trade consists of both uncleaned and cleaned cotton.

(a). *Uncleaned Cotton.*

Uncleaned cotton, comes entirely from the neighbourhood of Indore, within a radius of from ten to fifteenth miles of the city. The season is from the fifteenth of November to the end of February. From October 1, 1918 to February 6, 1919, the total number of carts entering the municipal godown was 2,030, coming in as many as 213 on one day. The number of carts of cleaned cotton during the same period was 3,046. It is impossible to ascertain the weight, for this information is not recorded in the books of the godown, and bales of uncleaned cotton may differ greatly in size and weight.

The greater part of this cotton is consumed by the local mills, which have their own ginning departments. Some goes to local ginning factories independent of the mills. The export from the city is negligible: in 1917-18 it was only 349 maunds, which was the largest exportation during the past ten years.

(b) *Cleaned Cotton.*

The following figures from the records of the municipal godown are instructive:—

	1916-17	1718-19.
No. of bales on hand, Oct. 1	... 6,416	14,516
Bales received during the year	... 68,729	45,332
Bales sent out " " "	... 60,629	54,916

Of this cleaned cotton imported into the city, only about 6 per cent comes by rail; the rest is brought in by cart. The principal districts of shipment by rail are Pimpla, Machalpur, Rampura via Garoth, and occasionally the Nimar district via Burwaha.

The radius of cleaned cotton import by cart is Rs. 40 per cart. This makes an effective boundary of Kannod, Khalghat, Kukshi and Khilchipur. Beyond Kannod the cotton will ordinarily go to Harda. Beyond Khalghat on the south side of the river it will go to Dhulia and thence to Bombay. Long stapled cotton may come from Kannod, not to the local dealers, but only to the mills for their own use. It is never exported from here.

The local mills are the chief purchasers of the cleaned and baled cotton, a little over 50 per cent going to them. Some 18 to 20 per cent is exported by rail to Cawnpore, Hathras and Bombay. Not over 3 per cent, however, goes from here to Bombay. Some 18 per cent is exported by cart, chiefly to Ujjain *via* Dewas. The journey occupies two days; the present cartage charges for a cart of ten bales are Rs. 11 per cart. The remainder of the cotton is left stored in the godown. Some bales have remained there for two years, at a charge of one half anna per bale for the first fortnight; second fortnight, 1 anna; additional time, 1½ annas. The charge seems low considering the service rendered.

The export of pressed bales of cotton has shown a marked decline during the past ten years, much more than counterbalancing the increase in exports of uncleaned and cleaned cotton. The following figures are illustrative:—

	Uncleaned.	Cleaned.	Pressed bales.
1910-11	318 mds.	91 mds.	39,796 mds.
1913-14	48 "	4,604 "	10 "
1915-16	100 "	1,052 "	10,920 "
1917-18	349 "	4,945 "	11,944 "

General direction of Trade.

From an analysis of the receipts of cotton it would appear that only about 12 per cent of the annual receipts

of cotton originate from east of Indore city, and from west of Indore about 75 per cent.

CHAPTER V.

The Cloth Market.

Location:—The main cloth market is located in Bazazkhana. The shops form the four sides of the square in the centre of which is a vegetable market. It is spreading into the small Sarafa and the other nearby streets. In the square is the headquarters of the Cloth Merchants' Association. There is an important retail market, also, in Kishanpura, and a smaller retail market in the Residency.

Merchants:—There are over three hundred cloth merchants in Indore, but of these only ten or fifteen carry on a wholesalè business, in addition there are the agencies of the local mills and of the Ujjain mill. The merchants are mostly Marwaris, although some come from Nimar. The institution of the cloth market as a market and the coming of the larger merchants dates back to the time of His Highness Tukoji Rao II. As part of his policy to develop industry and commerce, he brought traders to Indore, and induced them to settle here by advancing loans and lessening the duties. In his time the trade of the market, it is said, increased to about 50 lakhs of rupees annually. Cloth bales were brought by bullock cart chiefly from Bombay, Nagpur and Agra. The journey from the latter place occupied from 20 to 25 days. With the coming of the railway the market for some considerable time decreased, because many places which had formerly purchased their goods through Indore were now able to secure them by rail direct. The trade became confined to a radius of 50 kos (75 miles) of Indore. During the past ten or fifteen years it has again increased because of the developement of the three local mills: The Malwa United, the Hukumchand, and the State Mills.

The Trade:—The trade today totals nearly a crore of rupees in value annually. It can be divided into two classes: (1) the trade in cotton cloth manufactured by the local mills; (2) the trade in cloth imported into the city from outside the State. The latter consists largely of foreign made cloth, for the local mills are protected against competition of Indian made goods by a duty of Rs. 7-13-0 per cent ad valorem; whereas all other cloth bears a duty of only Rs. 1-9-0 per cent ad valorem. The importation of India-made cloth, according to the returns has rapidly declined during the past ten years. In 1910-11 it was valued at Rs. 1258. In 1917-18, even with the tremendous increase in prices, it was worth only Rs. 86! An explanation may be that good Indian made cloth is passed as foreign in order to avoid the enhanced duty.

Imports of foreign cloth, and of Indian cloth above 20 counts, and Indian silks, have rapidly increased in value. In 1910-11 they were worth Rs. 17,95,786. By 1917-18 they had almost doubled, totalling Rs. 33,15,417. Of this amount only about three per cent is silk and wool, the balance is cotton. Despite the penetration of Japan into the local market, it is declared that only three per cent of the foreign cloth in Indore comes from Japan; the balance is from England and Scotland.

The trade of the local mills through the city wholesale market is estimated at from Rs. 50 lakhs to Rs. 60 lakhs. Because of the increase in prices it is expected to be Rs. 70 lakhs this year. Practically the mills deal only with the wholesalers in the local market, because the terms of 20 days' credit do not suit the smaller dealers.

The Direction of Trade:—The consumption of Indore city itself, including the Residency, is estimated at about Rs. 27 lakhs. Of this only about Rs. 2 or 3 lakhs is of cloth of Indore manufacture. The residents of Indore appear to prefer cloth of counts higher than those which are manufactured in any quantity at the local mills. In

ascertaining the direction of trade the distinction must again be made between cloth of Indore and cloth of foreign manufacture.

(1) *Cloth of Indore Manufacture.*

The approximate distribution is as follows:—

- 5 per cent purchased in Indore city.
- 20 per cent exported by cart from Indore.
- 75 per cent exported by rail from Indore.

Cloth is sent by rail to merchants, either through agents resident in Indore or agents who come here, as far north as Amritsar, Rawalpindi, Delhi and Cawnpore; and to the south to Khandwa, Jubbulpore and Ahmedabad. Despite the fact that Ahmedabad is an important cotton manufacturing centre, it is said that Ahmedabad consumes as much cloth of Indore manufacture as does Indore itself. The bulk of the trade, however, is with the north and the east, rather than with the south or the west.

By cart cloth is sent within a radius of cartage charges of Rs. 20 per cart. There is no export into Gwalior, but a very considerable export into Dewas. The effective radius appears to be Narsingur and Kannod on the east, or occasionally Khategaon; and Khilchipur; and Rajgarh on the west with occasional shipments into Jhabua. The following statistics show the exports of cloth from Indore city into Indore State during the months of November and December, 1916. The bulk of this cloth is of local manufacture. Exports into surrounding States are not included. With them it is probable that the value of the trade is practically equal towards the west and towards the east of the city.

Kannod side	...	Rs. 15,508
Dewas	„	33,189
Dhar	„	11,880
Depalpur	„	31,711

Total Rs. 92,288

(2) *Cloth of Foreign Manufacture.*

The greater part of this cloth is consumed in Indore city. Very little of it goes into the district or to the surrounding States, except to the larger centres which have an educated or wealthy nucleus. About 25 per cent of the imports are re-exported by rail to such centres as Mhow, Ujjain, and others within a radius of 100 miles of Indore.

The Cloth Merchants' Association:—This is an association embracing the majority of the wholesale and retail cloth merchants of the city. Its aim is to develop the market; but the practical function of its committee has come to be the settlement of disputes, acting as an arbitration or conciliation board. In this it appears to be successful. It is said that in the cases brought before it during the three years of its existence, it has failed to settle only 5 per cent. Not only does it save the costs of disputes referred to the courts, but it overcomes the delays attending legal proceedings. The committee at present in charge are: Rodhuram Nindram, Nandlal Bhandari, Radhakisan, (of the business of Rupchand Ramdayal), Bijoram Shivkisan, Lachimi Narayanji Fasali, Ramratan Tikandas, Mohanlal Bisandas, Hanmandas Ramanand, Kesarimal Bakhbwala, Hiralal.

Improvements suggested by Merchants:—

1. Lower Railway rates,—at present the rate is Rs. 1 as. 4 per maund from Bombay to Indore.
2. A broad gauge rail connection from Godhra or Dohad on the main line B. B. & C. I. through Barwani, Dhar to Indore. The real value of a broad gauge, however is disputed by some of the larger merchants.
3. More local mills. The present development of the market is largely due to the local mills. More would still further increase it.
4. A State Bank. A State Bank, it is said, would give better terms to the merchants than an outside bank,

since its whole interest would be the development of the Indore market. At present the merchants secure additional funds from the Sarafa. But in the Sarafa, it is pointed out, a banker reserves about one half his funds for his own trading, and the full funds of the money market are thus not available for the local merchants.

5. A lessened or a removed customs duty,—a free market such as that in Shiaganj. The present tariff gives receipts of Rs. 51,809. It is urged that this would soon be made up by the business tax upon the increasing trade of the market.

CHAPTER VI.

The Grain and Provision Market.

Location:—The grain and provision market has three important branches; (a) Malharganj; (b) Shiaganj (c) Indore Residency. Malharganj is situated within the city proper near its extreme western limit. Shiaganj is the city's free zone, south of the passenger station, and at some considerable distance from the freight godown. The Residency market is in the center of the Residency, and many of the godowns are in the square back of the vegetable market.

The Merchants:—In Malharganj there are about 15 wholesale merchants, and 40 commission agents. In Shiaganj there are 30 wholesalers dealing in grain, cotton and kirana. In the Residency there are not over 10 wholesalers, including the agent of the large flour mill, and the agents of Railli Bros., who have godowns in Shiaganj and their offices in the Residency. During the past year there have also been in the Residency a number of Gujeratis who have bought what wheat was offered at exceptionally high prices to help make up the shortage in Gujerat.

In Malharganj the majority of the houses are of long standing. Four do a business, it is said, of over three

lakhs per annum, one as high as 20 lakhs. In Shiaganj there are six branches of Malharganj firms; branches of firms in the Sarafa; and two or three firms whose headquarters are outside Indore. For instance one has its head office in Bikaner, with branches in Calcutta, Bombay, Cawnpore, Jaunpur, as well as in Indore. There are in all about 15 Marwari banias and 15 Kachis. The latter as a rule, do not engage in the commission business, and confine their activities chiefly to kirana. They seldom bring their families to Indore; but, after conducting their business during the seasons, they return to their home during the rains, and their shops are closed for about four months. Their homes are mostly in Gujerat or Kathiawar. The banias originated in Marwar. Although some of their families have been in Indore for almost fifty years nevertheless the majority have come during the past twenty five years because of the free market of Shiaganj.

The Volume of Trade:—It is exceedingly difficult to estimate the amount of the grain trade during an ordinary year. Dependence must be placed almost entirely upon the opinion of the larger merchants who should have a knowledge of the market, for there are no statistics which cover all three markets in all respects. Opinions unfortunately differ widely. For instance, the amount of wheat was placed as low as three kanassa by one merchant, and as high as 2,500 kanassa by another; and rice was estimated at from 60,000 to 160,000 bags. The following figures for one year's trade in all Indore markets have been arrived at after consideration of the statements of merchants, bazar inspectors, the Residency records of 1918, the sayar records of imports into Indore, and an analysis of the transit passes issued from Indore during the months of November and December, 1916:—

Wheat	...	10	kanassa or 6,00,000 maunds.
Jowar	...	10	„ or 6,00,000 „
Macca	..	2 to 3	„ or 1,20,000 to 1,80,000 mds.

Bajra	...	1 to 2 kanassa or 60,000 to 1,20,000 mds.
Sugar	...	50,000 bags
Gur	...	1,00,000 bags
Ghee	...	15,000 tins.
Rice	...	70,000 bags.
Salt	Rs.	50,000
Linseed	...	5 to 5 kanassa or 2,40,000 to 3,00,000 mds.
Khajur	...	25,000 bags.
Cocanuts	5,000	„
Batel Nut	5,000	„
Potatoes	10,000	„
Tamerine	5,000	„

The trade in kirana centres chiefly in Shiaganj. Probably not more than 25 per cent of it is done in the Residency, and very little is sold in Malhaganj. The grain trade appears to be divided almost equally between the city and the Residency with the export trade of the city centred chiefly in Shiaganj, and the local trade in Malharganj. During the past year, since the prohibition of export of grains by the State, the importance of Malharganj has again increased; the trade of Shiaganj has greatly diminished; and the export trade of the Residency has been practically confined to the grain which comes to it in transit by cart from surrounding States, and to the accumulated stocks of the dealers. For example during September and October, 1918, the agent of the Flour Mill was permitted to export 4,000 bags of wheat, which had commenced to spoil, on condition that a certain quantity was sold at a greatly reduced rate to the poor people of the Residency. The carts of wheat received in transit in the Residency market during the months of April, May and June, of 1918 totalled 2,325. Of these 1,828 come from Gwalior State. Undoubtedly they were attracted here by the exceptionally high prices offered by the Gujeratis, which enabled them to pay the export duties charged by their own States. The price prevailing in

the Residency was always Rs. 10 or more above that of the city markets. In one week in September wheat sold as high as Rs. 55 per mani. (Rs. 9-2-8 per maund).

The Import Trade.

(a) *By Cart.*

The import trade by cart is in the following principal articles:—

Wheat	Linseed	Bajra	Jowar
Macca	Ghee		

The main sources of supply are within a radius of Rs. 25 cartage charges. This makes a boundary of Kannod on the east; Jhabua on the west; Kukshi on the south and east; and Tonk in the north and west.

Wheat:—The importation by cart is divided approximately as follows:—

Sipri Valley, Dewas and Gwalior	...	25 per cent
Depalpur District	... ..	20 „
Betma District	... ..	20 „
Dhar	... ..	20 „

The balance comes from as far west as Jhabua, and as far east as Kannod. Pissi wheat is imported from the Kannod side, although it is five or six years since it has come from as far as Kannod itself. Wheat from Dewas and Gwalior is sold very largely in the Residency market. Probably 70 per cent of the wheat exported from Dhar comes through Indore, either to Malharganj or through the commission merchants in Shiaganj. The remainder of the Dhar export is by Mhow and Barnagar.

Jowar:—The importation by cart is divided approximately as follows:—

Kannod District	... ..	12 per cent
Dewas	... ..	30 „

Hatod district	..	...	25 per cent
Bauganga district		...	19 „
Dhar district.	...	...	14 „

Linseed:—The importation of linseed is divided as follows:—

Kannod district	...	...	12 per cent
Dewas	„	...	25 „
Bauganga	„	...	12 „
Hatod	„	...	20 „
Dhar	...	...	31 „

Macca:—The importation of macca is divided as follows:—

Kannod district	...	...	6 per cent
Dewas	„	...	25 „
Bauganga	„	...	19 „
Hatod	„	...	14 „
Dhar	„	...	36 „

Ghee:—Ten years ago, it is said 75 per cent of the ghee came in by cart. Two years ago 50 per cent came by cart. To-day not over 12 per cent comes in that way. The Nimar, Jirapur and Machalpur, which formerly were exporting districts, are now importing. At present some ghee comes from Gwalior and Dhar and Bhopal, but most of it comes from Indore State.

(b) *Import by Rail.*

The import trade by rail is in the following principal articles:—

Wheat	Ghee	Sugar	Rice	Haldi
Potatoes	Kirana	Gur'	Salt	Nuts
Tamerine				

Wheat:—When Punjab wheat is considerably cheaper than Malwi wheat from three to four kanassa are imported; and the same quantity of Malwi wheat is thus released for export. Some wheat from Gwalior comes down via Ujjain or Barnagar. Malwi wheat is favored in the market because of its superior milling and cooking qualities. It is generally quoted as the most expensive wheat in India.

Ghee:—Ghee is imported by rail from Cawnpore, Hindaun, Gangepur, Ujjain, Rutlam, Burhanpur, Khandedh. Certain Bhopal districts which formerly exported to Indore are now sending direct to Calcutta as a result of the opening of the Ujjain-Bhopal line.

Sugar:—Mauritius sugar comes from Bombay and Calcutta and—since the war—from Madras. Indian sugar comes from Cawnpore.

Gur:—From Lakhanpur, Gola, the Cawnpore District, Delhi, Sangli in Belgaum, and Barsi and Haramati in the Deccan near Poona.

Rice:—From Naugar, Nagpur, Raichur, Gondia, and Rangoon via Bombay or Calcutta. During a great part of 1918 the Burma rice was not available, and importation into Indore by broad gauge from Calcutta was practically impossible. Naugar and Raichur districts supplied the greater part of the local demand. This demand considerably increased owing to failure of the jowar crop the previous year.

Salt:—Practically all salt comes for Khargoda District.

Haldi:—Haldi comes from the Purab district of the United Provinces, and also from Madras and Barsi.

Potatoes:—From December to March potatoes are imported from Farukabad and Kamalganj.

Nuts:—Cocoanuts are imported chiefly through Bombay, Calcutta, and Madras. It is said some of them come

from Travancore. Khajur is imported through Basra and Bombay from November to February. Walnuts come from Mussooree, and from other hill stations in the Himalyas.

The Export Trade.

(a) *By Cart.*

The Indore market is the source of supply not only for the greater part of Indore State, but for the surrounding States as well. The following table of exports from the Residency and Shiaganj,—the export centres for grain and provisions—for the two months, November and December, 1916, into surrounding States is instructive:—

State.	Rice bags.	Sugar bags.	Ghee tins.	Sweet oil bundles.	Gur.	Tobacco bales	Kirana bundles	Kerosine tins.
Gwalior.								
Shiaganj ...	94	100	14	9	0	58	335	1119
Camp ...	102	77	11	3	0	7	947	732
Dewas.								
Shiaganj ...	266	230	189	22	0	132	2301	668
Camp ...	52	45	50	10	0	13	173	460
Dhar.								
Shiaganj ...	422	717	295	116	0	125	2671	3407
Camp ...	113	197	34	39	0	38	1225	747
Small States								
Shiaganj ...	885	820	265	83	46	124	1897	600
Camp ...	177	216	101	2	0	35	2739	366

During the same period the value of similar goods exported from the City proper into Indore State was as follows:—

Depalpur side.—Kirana Rs. 147; Ghee Rs. 30.

Betma and Nimar.—Kerosine tins 4; Red pepper Rs. 25

Dewas side.—Kirana Rs. 10.

Kannod side.—Kirana Rs. 68; Red pepper 2 bundles; Ginger Rs. 160; Vegetables Rs. 1011.

It is impossible to ascertain the exact figures of the exports from the Residency and Shiaganj for the same period into Indore City and Indore State. However, they cannot be less than into the other States. The conclusion is inevitable that this large and lucrative business is practically entirely in the hands of the Residency and Shiaganj—neither of which is under the jurisdiction of the Sayar Department of the State.

A feature of the cart export during the past few months has been the large export of Jowar into the Nimar. In two months, December and January, it is said that 100,000 bags went in that direction; and it is probable that some of it found its way to Bombay.

In normal times it would appear that the export by cart from Indore in this market is 75 per cent of the total export, and that the export by rail is 25 per cent. Of the cart export, almost 65 per cent goes to the Nimar or Dhar side; and some 35 per cent to the Dewas or Kannod side. that is west and east of Indore respectively.

(b) Export by Rail.

The distribution of grains by rail depends largely upon seasonal conditions both in the determination of quantity and of direction. Generally speaking, the export of Linseed amounts to the entire crop. Of it, 85 per cent goes to Bombay for export, and the remainder goes to places on the Nagpur side. Of macca and jowar 50 per cent are exported, largely by rail. Some 25 per cent of the jowar may go to Berar, the rest to Bombay and Gujerat. Before the war much of Indore's wheat was exported. The present rail export is entirely from the Residency market, and it is principally to Gujerat. The general grain market extends as far as Harda and Burhanpur; to Rutlam and the Ujjain-Bhopal line; and to Marwar, Gujerat and Bombay.

Improvements suggested by Merchants.

(a) *Shiaganj.*

1. An increase in the area of the free zone. The present congestion at times completely blocks the main road; and what was once the city's widest street is being built up by godowns in front of the shops because there is no room behind. The influx of merchants has forced up rents; and some have requested State control of rents. The size of the present free zone makes impossible any considerable development of trade.

2. A market place or chowk is urgently needed capable of accomodating several hundred carts. The present chowk is not readily accessible, and consequently much of the trading with the cultivators takes place on main roads. It is pointed out that the failure to supply proper market-facilities both in Shiaganj and Malharganj is an important reason for the large grain trade of the Residency, where a commodious adda has been built. It is further stated that in the city markets cultivators must sometimes wait two days before they can dispose of their loads and return home; whereas in the Residency market they never have to wait longer than one day.

3. An association of Shiaganj merchants on lines similar to the Cloth Merchant's Association is desired by some. Any such organization would be successful only if it were formed under the guidance of the Commerce Minister.

4. Emphasis is placed upon the necessity of a broad gauge railway. The two lines mentioned are Indore to Rutlam, or Indore to Ujjain *via* Fatehabad. At present there is considerable loss both of time and material in the trans-shipping at Rutlam and Khandwa. Indore's market is largely north and east, and with Bombay City, all of which can be reached by Rutlam. Accordingly not much emphasis is placed upon the necessity of broad gauge

connection with Khandwa. Certain light railways are suggested, but only on condition that they terminate in the market and not at the present railway station. These lines are: Dhar to Indore; or Rajgarh to Indore, *via* Hatod and Betma; and Dewas to Indore *via* the Sipri valley. Were direct connection made with the railway, it is believed that Shiaganj's trade with surrounding States would suffer a loss of 50 per cent. A direct connection of the market with the railway by a switch line, as Prof. Geddes proposed in his report, is regarded favorably by the merchants.

5. There is strong demand both in Shiaganj and in Malharganj for better banking facilities. At present the merchants borrow amongst themselves, or bring money from the bankers in the city. The Bank of Bombay, which formerly had a branch in the city, now only has a branch in the Residency. It has practically no direct connection with the merchants, but deals with them only indirectly through the bankers of the Sarafa. The merchants say that frequently the funds available are not sufficient to enable them to take full advantage of market conditions. This is aggravated by the fact that only one half of the funds of a banker are available for loan, and the banker himself as a trader may be a competitor of the merchant in Shiaganj. The merchants desire a State bank, or a joint stock bank controlled by the State, willing to discount traders' paper and to give loans on goods sealed in the merchants' own godowns, which the Presidency banks are not able to do.

(b) *In Malharganj.*

1. The merchants unite with the Shiaganj merchants in advocating: (a) better market facilities; (b) a State controlled bank; (c) broad gauge connection with Rutlam, and light railways into the State.

2. They ask for permission at present to export surplus wheat over and above the needs of the State. A State

store or an export tax is preferred to the total prohibition of export now in force. Wheat, they say, can only be stored for two years, and some merchants under present conditions feel that they may lose. If prices are forced down, then cultivators will suffer in lower prices for their next crop. During the cold season prices were about Rs. 10 higher per mani in the Residency than in the city for wheat. It is argued that an export duty on wheat would materially add to the revenues of the State.

3. The suggestion was made for a municipal, rat-proof godown. The majority of the store rooms in Malharganj used at present are rented, and none is rat proof, nor free from insects. The loss from rats is estimated at one per cent per annum of the the stored wheat; and from the red and black insects which work in the grain, two per cent. A municipal godown, for which it is said there is land available just west of Malharganj, would find ready support.

CHAPTER VII.

The Iron And Hardware, And Paper Markets.

Location:—The market is located in Shiaganj to the west of the grain market. The city market is in the Bohra Bazar near the cloth market. There is one large shop in the Residency. Three large paper shops are in the Sarafa, just beyond the Old Palace.

The Merchants:—The wolesale merchants do not number more than fifteen. Of these five are large paper dealers. One shop in Shiaganj has been opened in February dealing only in paper. The merchants are all bohras, and possess on an average a capital of Rs. 75,000.

Import of Iron and Hardware:—The value of the wholesale trade is difficult to estimate. The only figures available are those for the city and are as follows:

Date.	New Metals and Utensils.	Metal sheets & Utensils
1913-14	Rs. 4,38,067	Rs. 2,16,490
1917-18	Rs. 1,89,434	Rs. 1,01,455

Of the import trade fully 85 per cent is with Bombay. The principal sources of supply for commodities are:—

1. *Bombay*:—Iron bars, galvanized iron sheets, wire gauge, safes, scales, superior nails, lead, trunks.
2. *Japan, via Bombay*:—Locks, paints, colours, lamps etc.
3. *Delhi*:—Lanterns, needles, locks, manyaris, buttons, lamp chimneys.
4. *Agra*:—Iron measures, sugar cane crushing machines
5. *Ratnagiri District*:—Cane crushing machines.
6. *Cochin & America, via Bombay*:—Rope, locks.
7. *Indore*:—In the local market the bohras manufacture such articles as phauda, kudal, ghamelas, weights, horse shoe nails, kudals, etc. and trunks. Many trunks both of steel and of wood covered by tin are made here now; and proposals are being made by at least one bohra to open a factory if he can secure a site free of rent in the new Industrial Town.

Destination of Iron & Hardware:—During the two months of November and December, 1916, the number of metal articles exported to the surrounding States from Shiaganj and the Residency was as follows:—

	Shiaganj	Residency
Gwalior	335	127
Dewas	236	23
Dhar	1146	37
Small States	457	161

An Important export of new metal takes place from Bohra bazar in the city into Indore State. During the same period it was:—

Depalpur side	Rs. 225
Dhar side	„ 3643
Dewas side	„ 3745
Kannod side	„ 1000; or including what goes to Barwaha, Sanawad and other stations in the State south of Indore, Rs. 16,810.

It is again impossible to estimate the export from the Residency and from Shiaganj into the State itself.

The chief places of rail export, apart from Barwaha and Sanawad, are stations within the radius of Nagpur, Bhopal and Rutlam.

The Paper Market:—Paper and Stationery come from Bombay, Calcutta, and to a small extent from Cawnpore. The Bombay papers are chiefly of foreign manufacture. Before the war they were European; now they are almost entirely from Japanese mills. The Calcutta and Cawnpore papers are chiefly of Indian manufacture. A large new shop dealing only in paper has recently been opened in Shiaganj.

CHAPTER VIII.

The Leather Market.

Location:—The market for the manufacture and the sale of country shoes is in the Machli Bazar. The purchase and sale of hides and skins takes place ordinarily at the Sunday market when the villagers bring hides to the city.

The Merchants:—There are four large merchants engaged in the export of hides, three with capital of

Rs. 10,000 each, and one with a capital of Rs. 15,000. There are probably 15 or 20 manufacturers of shoes.

The trade:—The trade must be divided into two branches: the export of hides: and the manufacture and sale of shoes.

(n) *The export of Hides.*

The export of hides has shown increase during the past ten years. The following figures are illustrative:

Year	Large Hides	Small Hides
1910-11	1290	18,485
1911-12	8447	22,760
1914-15	1988	16,647
1915-16	5876	32,129
1917-18	3086	29,529

Indore is the exporting centre for hides for the entire Indore district. The export in 1917-18 from all the other stations in the district totalled only 361 large hides, and 1,772 small hides.

The hides dealt in are chiefly the hides of buffalos, cows, bullocks, goats, deer, and on rare occasions, camel.

An untanned hide of a cow bullock or buffalo is worth from Rs. 2 to Rs. 4 for a hide weighing roughly 7 to 8 pounds.

There is no tanning factory, in Indore, although this work is done in certain villages such as Double Chowk and Betma. The majority of the hides are exported to Cawnpore, Calcutta, Lucknow, Delhi where the best tanning is done; and also to Rutlam, Jaora and Mhow.

(b) The Shoe Market.

Leather for the manufacture of shoes,—chiefly cow bullock and buffalo hides—is obtained from the various tanning centres. A considerable trade is done, not only with Indore city, but with the surrounding district., The following figures of exports during November and December, 1916, are illustrative:

Kannod side:	Rs. 908
Dewas side :	Rs. 700
Depalpur side:	Rs. 40
Dhar side:	Rs. 584

Suggestions for Improvement:—A tanning factory in Indore.

CHAPTER IX.

The Gold and Silver, the Share and Speculation Markets.

Location:—These markets are located chiefly in the Big and Little Sarafa. The centre of the gold and silver market is in the Little Sarafa; the centre of the share and speculation markets is in the Big Sarafa; but the latter business is carried on also by the gold and silver merchants and to some extent throughout the entire city.

The Gold and Silver Market:—There are no merchants in this market who carry on only a wholesale business. The majority combine a retail business with the wholesale, while at least a third of the merchants are only retail dealers. The capital of the retailers is from Rs. 2,000 to Rs. 10,000; that of the wholesalers and retailers runs in some cases into lacs.

The wholesale import business is carried on chiefly with Bombay, where some of the merchants have their

own shops. One firm at least has its branches throughout the east as far as Japan. Occasionally foreign business is conducted by a temporary combination of merchants, who dissolve connection when it is completed.

The Indore market supplies Indore City and Indore State and the surrounding district of Dhar, Dewas, Ujjain, Barwani, etc. Business with these States is through dealers in each State who have their own branches in Indore.

The commodities dealt in are gold, silver, pearls, and other, precious stones, and ornaments made from these. The extent of the business may be judged from the following figures of the import of gold and silver into Indore City.

Year.	Gold.	Silver
1910-11	Rs. 20,471	Rs. 9,79,872
1912-13	„ 30,246	„ 10,77,293
1913-14	„ 23,339	„ 17,30,882
1914-15	„ 6,246	„ 11,06,268
1916-17	„ 29,074	„ 1,45,031
1917-18	„ 10,492	„ 1,23,400

During the two months of November and December 1916, the exports of gold and silver from the city to the districts of Indore State were: Gold Rs. 909; and Silver Rs. 20,345. Of this amount Gold to the value of Rs. 690 and silver to the value of Rs. 17,250 went to the Dhar side. During the same period the export of gold and silver to the surrounding States amounted to only Rs. 61, to Gwalior.

In this market all transactions are registered at what is called the "Dhurm Khata". It is conducted by a panchayat, and contains all kinds of weights. All purchases are taken there to be weighed and registered, and the weights are final. The charges are: 2 pice up to 5 tolas weight, 4 pice from 5 to 10 tolas, etc.

The Share Market:—Dealing in shares in companies, as distinct from dealing or speculation in commodities, is increasing in the city, although probably only 25 per cent of the investors or speculators even yet are interested in this market. Until recent months the market was very largely confined to the merchants of the city. An investment bureau is now operating, however, which is making its appeal to the more educated classes, and which is attempting to popularize shares of the Bombay and Calcutta markets amongst these classes.

Of the dealers in shares it is said that about 25 per cent are speculators, who are gambling on margins, and the remainder are actual investors in the companies. Of the speculators the majority are bunnias,—it is said that 80 per cent of the bunnias dealing in this market are speculators.

The most popular shares—and the ones in which there is most speculation—are “locals”. They are Indore Malwa, Hukumchand Mills, Binod Mills; Iron Foundry; and Brush Factory.

Other shares which are dealt in here are:

BANKS:—Bombay, and Tata Industrials.

COTTON MILLS:—Bombay Dyeing; Bombay United; Crescent; Currimbhoy; Fazalbhoy; Indian Bleaching; Kohinoor; Madhaosi Dharamsi; Shapurji.

OTHER COMPANIES:—Alock Ashdown; Bunda Lime; Bombay Burma Trading; Central India Mining; Indian Cement; Tata Iron and Steel; Tata Iron and Steel, Deferred; Tata Hydro; Tata Oil Mill.

Practically the entire business is carried on through brokers. Their charges are As. 8 per share on locals. The period of greatest activity is July and August. During these months, because of the rain, there are few other openings for investment, and the bunnias especially then turn their attention to speculation.

The Speculation Market:—Speculation centres in the Big Sarafa, although it is carried on throughout practically all bazars. It may be conducted in anything, but it is chiefly in rain, the opium average, sugar, gold and cotton.

Speculation in gold is extensive because of the smallness of the unit, which is 25 tolas with a deposit of Rs. 25. Fluctuations are of annas, so that the losses and gains in single transactions are not very great. Speculation in cotton, on the other hand, is in large units. In Malwa cotton it is of 5 boge (1 mani is equal to 2 to 3 boge.) In Broach cotton the unit is 100 khandi. In this market the gains and losses are very great.

In the speculation market it is not customary to take delivery of goods upon sale. Thus in the cotton speculative market it is not necessary for the commencement of the speculation for the seller to hold actual cotton in the municipal cotton godown. He may offer cotton for sale, and transactions may then take place until full moon day, the settlement of the various transactions being made simply by the adjustment of differences. At full moon day, commencing about 7.30 in the evening, the dealers meet together to make their monthly adjustments. This must be done before fresh transactions can be entered into. At the settlement it is at the option of the last buyer to demand delivery of goods, or to settle the balance in money. It is said that in this market in only 10 per cent of the cases is delivery actually taken in commodities.

The speculative price of Malwa cotton does not necessarily determine the price at which the cotton in the cotton godown is sold. The cultivators through their brokers who are generally the local brokers of village bunnias,—who are bound to get the best possible price for their customers—deal with the local merchants either at their place of business or actually at the municipal cotton godown. The greater part of the cotton is sold to the mills, and only a small proportions of it is bought by dealers for speculative

purposes. It is those who have these supplies on hand who are most likely to succeed in the market, for then they can always meet demands for settlement in goods.

Bargains are conducted largely by word of mouth, and at the final settlements it is said that fully 50 per cent fail to keep their word. Recourse, however, is seldom had to the courts because of the additional expense and the time involved. Such men become known to the dealers, who thereafter refuse to deal with them.

THE OPIUM AVERAGE:—Speculation in the opium average is conducted in a different manner. The Government auctions opium monthly in Calcutta, with a set reserve price per chest. The first method of betting is upon the figure which at the auction will become the last digit. It may be any figure from 0 to 9. Should a man bet upon the proper figure he will receive Rs. 9 for every Rs. 1 which he bets. Thus if he bets Rs. 10 upon the figure 5, and the auction price should be Rs. 3,245 (when the fixed price is Rs. 3,200) or any other figure ending in 5 he would receive Rs. 90.

The second method of betting is upon the last two digits. There are thus 99 different possibilities. The unit for the bet is between Rs. $1/8$ and Rs. 2. If the speculator should win he will receive Rs. 100 for every unit bet. Thus if the unit is Rs., 2 and he has bet Rs. 20 and wins, he will receive Rs. 1,000. This form of speculation goes on throughout the year, and the rate is declared between the first and the tenth of each month.

Of the transactions in the share and speculation markets, it is said that 75 per cent are purely speculative.

Suggestions:—Suggestions which have been made by those interested in these markets are:—

1. That litigation be permitted in all cases of speculation. It is understood that it is now permitted only in speculation in Malwa cotton.

2. That there be a separate share market; and that there be a bank located in the Sarafa.

3. That there be a separate compound for speculators so that they will not crowd on to the narrow streets of the Sarafa as they do at present.

PART II.**Tables of Statistics.**

The tables of statistics shown hereafter are as follows—

1. Tables of Imports into Indore City of certain commodities, 1910-1918.
 2. Table of exports from Indore City of certain commodities, 1910-1918.
 3. Table of Imports into, and of Exports out of Indore City by Nakas in the year 1917-18.
 4. Table of Imports into, and of Exports out of Indore District in the year 1917-18.
 5. The Number of Transit and Transport Passes issued in Indore city by Nakas in the year 1917-18.
 6. The Number of Transit and Transport Passes issued in Indore City by Nakas in the year 1916-17.
 7. The Number of Transit and Transport Passes issued by Districts for articles coming into Indore City in the year 1916-17.
 8. The Export Trade from Indore City proper into Indore State in November and December, 1916-17.
 9. The Transit Trade of Shiaganj and the Residency with surrounding States in November and December of the year 1916-17.
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1. Table of Imports into Indore City of Certain Commodities 1910-1918.

Year.	Rice.	Mauritius Sugar.	Indian Sugar	Kirana.	Ghee.	New metal etc.	Old Metal, sheets.	Cloth Indian.	Cloth other.	Timber 1st.	Timber 2nd.	Gold.	Silver.
	Mds.	Mds.	Mds.	Value. Rs.	Mds.	Value. Rs.	Value. Rs.	Value Rs.	Value. Rs.	Garis.	Garis.	Value. Rs.	Value. Rs.
1910—11	36,490	23,306	13,398	4,70,040	5,413	1,75,105	1,68,673	1,258	17,95,786	1,453	1,274	20,471	9,79,872
1911—12	39,327	17,372	21,039	4,79,005	6,034	1,95,370	2,27,345	581	21,67,554	1,592	969	35,132	10,78,125
1912—13	43,704	27,960	16,339	5,19,533	9,311	3,10,087	2,10,641	677	24,67,837	2,719	1,672	30,246	10,77,293
1913—14	43,083	26,628	16,971	5,04,524	6,730	4,38,067	2,16,490	448	27,36,198	3,528	1,644	23,339	17,30,882
1914—15	50,480	9,466	29,453	5,11,726	5,686	2,67,583	95,393	1,999	22,36,281	2,293	904	6,246	11,06,268
1915—16	42,769	15,331	22,713	5,71,150	8,926	2,62,920	1,31,769	98	30,18,197	1,601	844	6,426	6,83,662
1916—17	47,321	12,923	24,828	7,32,898	9,042	2,04,864	1,53,304	323	27,36,116	1,862	1,289	29,074	1,45,031
1917—18	43,222	19,270	22,476	7,48,876	5,519	1,89,434	1,01,455	86	33,15,417	2,263	747	10,492	1,23,400

II. Table of Exports from Indore City of Certain Commodities 1910-1918.

Year.	Uncleaned Cotton.	Cleaned Cotton.	Pressed Bales of Cotton.	Hides ; large.	Hides small.	Ghee.	Tobacco.
	Mds.	Mds.	Mds.	Number.	Number.	Mds	Value. Rs.
1910-11 ...	318	91	39,796	1,290.	18,485	32	38,027
1911-12 ...	15	1,464	28,874	8,447	22,760	65	37,274
1912-13 ...	15	872	13,617	6,537	19,667	78	63,478
1913-14 ...	48	4,604	10	1,358	21,740	140	20,301
1914-15 ...	10	1,334	3,282	1,988	16,647	171	41,086
1915-16 ...	100	1,032	10,920	5,876	32,129	68	45,560
1916-17 ...	97	793	7,349	1,863	27,997	184	49,946
1917-18 ...	349	4,945	11,944	3,086	29,529	536	55,994

III. Imports into, & Exports from Indore by Nakas in Certain Commodities 1917-18.

IMPORTS 1917-18.

EXPORTS 1917-18.

NAKA.	Rice.	Sugar Indian	Sugar Mauritius	Ghee.	New Metal.	Old Metal.	Cloth Foreign	Cloth Indian	Gold	Silver.	Hides small	Cotton uncleaned	Cotton cleaned	Cotton Pressed Bales.	Tobacco
	Mds.	Mds.	Mds.	Mds Sr.	Value	Value	Value	Value				Mds	Mds	Mds.	Value
Ranipura ...	38,366	20,256	16,472	4,822	1,03,069	23,195	2,50,794	83	187	41,606	16,960	...	922	214	1,025
Edward Hall ...	707	204	198	429	21,330	14,194	4,62,699	...	411	45,386	3,082	...	115	11706	74
Sutyanttra ...	61	30	9	30	55,291	61,998	23,39,934	...	...	...	2,999	334	3891	...	213
Khadkladya ...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Lubrya Road ...	85	...	...	2	120	146	...	...	...	...	3	...	9	...	14
Dasera Road ...	16	...	1	...	18	355	221	...	...	...	200	13	8	...	...
Bhorkua ...	2,471	1,172	1,961	72	4,299	3	17,106	3	...	...	32	...	...	...	...
Patankar Chatri ...	931	510	240	62	1,374	307	339	...	...	12	6,110	...	...	...	8,595
Jana Indore ...	21	2	4	5	182	250	30	...	...	...	42	2	...	...	46,079
Khudol Road ...	74	27	9	4	269	1	28	...	...	...	...	...	...	...	...
Factory ...	99	11	29	111-20	2,442	209	7	...	...	...	...	...	...	24	3
Palasia ...	391	224	346	81-20	772	716	768	...	...	708	...	...	...	...	...
Old Sayar ...	...	...	1	...	263	...	2,43,490	...	9,854	35,688	91	...	...	...	...
TOTAL ...	43,222	22,416	19,270	5,519	1,89,434	1,01,455	63,15,417	86	10,492	123,400	29,519	349	4945	11,944	55,994

IV

Indore District.

IMPORTS 1917-18.

EXPORTS 1917-18

NAKA.	Rice.	Sugar Indian.	Sagar. Mouritius	Ghee.	New Metal.	Old Metal.	Cloth Foreign.	Cloth. Indian	Gold.	Silver.	Hides small.	Cotton unclean ed.	Cotton cleaned	Pressed bales cotton.	Tobacco.
	Mds.	Mds.	Mds.	Mds.	Value. Rs.	Value Rs.	Value. Rs.	Value. Rs.	Value. Rs.	Value. Rs.	No.	Mds.	Mds.	Mds.	Value. Rs.
Choral ...	16	1	55	0-20	117	10	541	...	...	150	...	...	...	...	...
Rao ...	2-20	9	7	10	4,835-8	6	439	...	...	...	...	...	...	...	...
Palia ...	7	10	14	23	760-8	...	1,011	25	...	150	...	...	...	...	7,884
DoubleChowki ...	6-20	3	4	...	...	...	560	...	...	7,552-12	1	...	...	...	...
Sipra ...	151	4	31	28-20	176	10,240	30,733	...	44	987-8	1	2	3	...	...
Chandrawatiganj..	201	290	60	8-20	890-8	9	1,989	...	3-8	87-8	40	1	...	...	3
Petlawad ...	244	...	2	76-20	208-8	142	2,595	49-8	3-8	3,068-8	306	212	6	...	300
Bamania ...	151	293	703	1-10	2,442-8	60	83,506	1050	164	...	20	10	1	...	1,283
Satarkhedi ...	75-20	21	27	21	385-8	...	88	...	...	...	4 ¹ / ₂	...	...	...	...
Yeshwantganj ...	16	3	9	2-20	455	58	63	8	...	25	...	5	8	...	...
Ajnod... ..	93-20	115	241	30	1,020-8	32	11,757	140	...	...	123	...	...	...	...
Dwiangargon ...	109	59	43	23-20	5,255-8	45	441	122	...	...	585	...	...	...	47,578
Gayakvad ...	419-20	45	54	39-20	526	...	2,250	51-8	...	650	199	...	...	...	...
Chambal ...	913	331-20	809	28	2,428	122	12,776	24	...	81-4	418	...	...	...	9,383
Atyanna ...	28-20	...	10-20	10-20	84-8	1,725	138	29	...	...	53	...	...	...	...
Nayapura ...	2-20	...	4	0-20	...	...	...	...	...	...	...	...	...	...	149
Chitawad ...	386	290	139	32	623-8	208	97	...	...	...	...	...	...	...	...
Deogararia ...	5	2-20	25	0-20	...	...	7	...	...	...	...	...	...	...	...
Kishanganj ...	215	51	52	17	1,843-8	1,866	23,166	2	...	...	...	75	...	...	...
Total...	3,043-20	1,528	2,289	357	22,073-8	14,523	2,87,881	1501	215	12,752-8	1,772	...	102	...	75,029

V.

Number of Passes issued in Indore.

TRANSIT 1916-17

TRANSPORT 1916-17.

NAKA.	TRANSIT 1916-17												TRANSPORT 1916-17.													
	October.	Nov.	Dec.	Jan.	Feb.	March	April	May	June	July	August	Sept.	Total	October	Nov.	Dec.	Jan.	Feb.	March	April	May	June	July	August	Sept.	Total
Ranipura ...	...	...	...	..	..	...	...	..	..	..	..	..	..	87	47	53	56	44	88	99	64	106	88	56	96	886
Edward Hall ...	...	...	...	...	...	...	...	...	...	...	...	...	...	99	163	77	64	55	71	97	42	62	65	55	7	860
Sutyantira... Khadkhadia Ghat ...	...	...	...	3	...	3	1	2	2	...	...	...	11	3	7	10	5	...	6	6	4	8	3	5	...	57
Bhoikua...	287	342	446	463	489	436	478	641	422	269	139	202	4574	..	...	..	..	..	..	..	..	..	..	..	..	..
Juni Indore. Patankar Chhatri ...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	...	...	...	...	...	...	...	...	...	...	...	1
Khudel Road	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	...	...	...	...	...	...	...	...	1
Factory ...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	...	...	1	...	8	7	...	10	5	...	...	32
Palasia ...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Old Sayar ...	186	189	189	281	219	136	171	248	217	98	78	98	2070	118	129	130	174	140	168	216	111	233	171	147	124	1831
Dasera Road	...	...	...	...	...	...	...	...	...	...	...	...	...	4	4	5	5	3	9	6	6	8	4	1	...	53
Labria Road	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Total ...	473	531	635	747	708	575	650	891	641	367	217	300	6735	313	290	275	304	242	350	431	227	429	336	261	290	3751

VI.

Number of Passes issued in Indore.

TRANSIT 1917-18.

TRANSPORT 1917-18.

NAKA	TRANSIT 1917-18.												TRANSPORT 1917-18.													
	October	Nov.	Dec.	January	Feb.	March	April	May	June	July	August	Sept.	Total	October	Nov.	Dec.	January	Feb.	March	April	May	June	July	August	Sept.	Total
Ranipura ...													144	103	98	282	443	401	296	130	360	189	164	202	3052	
Edward Hall ...													109	75	93	72	57	65	52	68	34	31	30	79	765	
Sutyantra... Khadkhadia Ghat ...			5						2			7	8	7	7	3	3	2	1			4			35	
Bhorkua ...	460	537	781	756	716	621	583	528	650	414	269	321	6636													
Juna Indore. Patankar Chatri ... Khudel Road ...																										
Factory ...										3			3													
Palasia ...																						2	1		3	
Old Sayar ...	197	107	208	236	923	230	376	452	367	285	150	146	8077	195	136	152	287	193	129	190	225	240	152	71	162	2162
Dasera Road Labrya Road ...														36	44	8	3	11	9	3	4	8	4	1	131	
Total ...	657	644	994	992	1039	851	959	980	1017	704	419	467	9723	492	365	358	647	707	606	542	697	644	381	266	343	6148

VII.

Number of Passes issued by Districts.

1916-17

TRANSIT.

for Goods coming into Indore Market.

TRANSPORT.

District	October	November	December	January	February	March	April	May	June	July	August	September	Total	October	November	December	January	February	March	April	May	June	July	August	September	Total
Upper Nimar	5	...	0	14	4	15	14	7	15	11	1	1	87	10	0	0	14	22	19	4	14	15	33	36	36	203
Lower Nimar	26	2	6	110	119	117	149	123	78	20	4	1	755	31	6	7	122	127	83	109	78	88	53	38	41	783
Rampura	2	...	0	5	10	8	38	12	17	7	0	3	102	7	5	14	7	9	16	21	5	18	8	6	10	126
Bhanpura	0	...	0	0	0	0	0	0	0	0	0	0	0	6	17	31	3	4	4	0	0	2	11	14	15	107
Mahidpur	0	6	4	0	0	0	0	0	0	0	0	0	10	11	6	6	50	23	20	15	24	22	19	27	33	256
Nemawar	0	...	0	0	0	0	0	0	0	0	0	0	0	9	3	9	54	29	21	27	26	16	10	7	8	219
Indore	15	53	95	83	88	89	50	24	25	14	4	14	554	49	149	137	114	127	223	60	79	127	66	79	78	1258
Total...	48	61	105	212	221	229	251	166	135	52	9	19	1508	123	156	204	364	341	386	236	226	288	200	207	221	2952

VIII.

The Export Trade from Indore City to Indore District,
November & December, 1916.

Sides.	Cloth.	Old Metal.	New Metal.	Kerana.	Cattle etc.	Glass etc.	Gold.	Silver.	Shoes.	Vegetables.	Ginger.	Yarn.	Miscellaneous.
	Value Rs.	Value Rs.	Value Rs.	Value Rs.	Value Rs.	Value Rs.	Value Rs.	Value Rs.	Value Rs.	Value Rs.	Value Rs.	Value Rs.	Value Rs.
Kannod side...	15,508	195	16,810	68	156	141	109	1,479	908	1,011	160	1,567	3,475
Dewas ,, ...	33,189	...	3,745	10	...	...	60	817	600	...	...	800	107
Dhar ,, ...	11,880	...	3,643	...	...	130	690	17,250	584	...	...	760	1,000
Depalpur ,, ...	31,711	15	225	117	...	...	50	799	40	...	...	700	296
Total ...	92,288	210	24,423	225	156	271	909	20,345	2,132	1,011	160	3,827	5,878

**IX. Transit Trade of Shiaganj and Residency with surrounding States
November & December 1916.**

State or District	Rice (bags)	Sugar (bags)	Kirana (undrs)	Kerosene (tins)	Metal (pulses)	Ghee (tins)	Cloth (bales)	Glass beads etc.	Gold and Silver.	Cattle (herd).	Jagrs.
Gwalior ...	{ Shiaganj Camp ...	124	147	504	1299	414	14	33	13	1969	..
		102	127	955	732	127	15	11	61	..	..
Dewas ...	{ Shiaganj Camp ...	266	230	2301	668	236	189	41	19	43	..
		82	45	173	460	23	50	3	43	..	..
Dhar ...	{ Shiaganj Camp ...	434	728	2806	2463	1171	293	90	6	..	..
		152	526	1437	817	75	34	22	..	..	..
Barwani ...	{ Shiaganj Camp ...	81	49	2345	20	150	..	3	..	..	..
		33	50	47	6	3	..	2	..	..	..
Mhow ...	{ Shiaganj Camp ...	643	866	720	135	84	202	1	..	190	..
		25	124	214	..	38	68	..	..	..	..
Mauipur ...	{ Shiaganj Camp ...	23	18	179	131	2	12	2	..	..	..
		5	16	28	10	..	3	1	..	..	..
Khilchipur	{ Shiaganj Camp ...	3	13	255	32	..	..	..	..	..	..
	
Narsinghrh	{ Shiaganj Camp ...	..	2	20	..	3	..	..	..	..	..
	
Patan ...	{ Shiaganj Camp ...	..	..	..	..	..	..	..	..	11	..
	
Jaora ...	{ Shiaganj Camp ...	..	..	..	..	..	..	2	..	..	..
	
Bhopal ...	{ Shiaganj Camp ...	..	..	..	3	..	..	4	..	..	..
		..	..	..	1	..	..	..	..	..	..
Miscellaneous	{ Shiaganj Camp ...	92	..	..	..	..	44	78	..	..	..
		76	..	..	..	..	58	3	..	..	..
TOTAL ...	{ Shiaganj Camp ...	1667	2053	9137	5749	2060	763	252	75	2213	..
		445	596	2854	2846	266	186	42	8	61	..

PART III.

CONCLUSION.

Certain problems present themselves as a result of this survey of the wholesale markets of Indore. They may be summed up under three heads: Sayar: Finance and Accommodation.

Sayar:—The organization of the Sayar Department, and the duties which are levied, do not come within the province of this report, except, in so far as they may mean undue interference with the market. I have two questions:—

(1) Why do not the Nakas surround only the Residency, Shiaganj, and the Railway Station, instead of being located, as is shown on the map, on the outskirts of the city?

(2) Why is it necessary to have the laborious and troublesome system of transport passes?

The general principle upon which a customs department should act is to interfere as little as possible with the trade of the markets. Acting upon that principle, why should there be constant interference with the road traffic by the nakas on the borders of the city, and by the system of transport passes? If the three foreign territories on the border of the State and city were sufficiently guarded by enlarging the nakas there, then all goods which pass them could be considered to be the property of residents of the State, and as such could pass freely within the State. The transit passes would be issued, and customs duties collected by these nakas.

The free passing of goods once the duty has been collected should be the aim of the Department. If the border system extends to all the borders of the State—as I presume it does from the list of the nakas in the Indore District,—then this aim should be readily fulfilled.

Finance:—The second problem is that of finance. The expressed desire of many merchants is for a bank, either run entirely by the State or controlled by it. The fact appears to be that the funds available in the city are not sufficient, or are at too high a rate, to enable the merchants to take full advantage of market conditions. Whether such a bank should be started, and if so, upon what basis, is not in my province here to discuss.

Permit me only to suggest that if such a bank be established, care should be taken that its funds be not used mainly for the exploitation of the market. In the grain market, for instance, where the demand for a bank is strong and from which much of the support of a bank would come, the difficulty of securing ready money is one of the forces which helps to keep down prices. If cotton is rising and wheat is low, the merchants wish to deal in cotton. At present they must frequently sell their wheat to secure the necessary funds. Were there a bank they would borrow on the security of their wheat, and thus keep it off the market until the price should come up. It is a legitimate business transaction. But the problem to decide is whether this form of business is desirable under the present distribution of income as between the merchant, the cultivator, and the State. It is a point which should receive careful attention in the operation of any bank for the benefit of the wholesale dealers.

A further question of finance is the establishment of credit with foreign houses, especially by the cloth merchants. The Indore cloth market is now sufficiently large for the merchants to buy direct from Europe or Japan, and not through intermediaries in Bombay. This is a matter which would require some organization, and it could probably only be done through the assistance of the Department of Commerce and Industries.

Accommodation;—It would seem that one of the advantages possessed by the Residency over either Shiaganj or Malharganj is the possession of a well appointed adda or market. Such markets should be established in the City. Suggestions for these have already been made by Prof. Geddes, and those recommendations I endorse.

Store rooms or godowns for grain are badly needed in both Shiaganj and Malharganj. Prof. Geddes has planned for grain godowns alongside a railway siding running into Shiaganj. They would provide for this Market. They would be the property of the municipality, and could be made to pay a revenue, especially if the privilege of building out onto the street in Shiaganj were withdrawn. The railway siding would be of material assistance in the shipment and receipt of grain and kirana.

In Malharganj similar godowns should be established. The fact that the majority of the store rooms at present in use are rented, and that vacant land is available in the neighbourhood, makes the proposition feasible. In both Shiaganj and Malharganj the aim should be to make the godowns rat proof, and to remove the stored grain from the neighbourhood of dwellings. Thus an attack may be made upon the rat and plague. The problem of keeping the grain free from the insects which so quickly destroy it should be referred to the Agricultural Department. If they should succeed in destroying these insects, there would be effected in the markets of Indore alone a saving every year at least 12,000 maunds of grain, or about Rs. 60,000. Protection against rats would save probably another Rs. 30,000.

A municipal godown for lumber does not appear to me to be a business proposition at present. Some organization amongst the merchants themselves might well effect the desired end.

Sanitary conditions in the several markets, where people congregate in large numbers, and especially where

food is exposed for sale, are absolutely essential. The practice of permitting verandahs to be built over the gutters or drains has, however, led to the accumulation of filth in those drains, especially in Malharganj and the Cloth market. When I was there some drains had not been cleaned for weeks, and the stench of the filth when I poked my stick into them was sickening. An essential characteristic of good markets is cleanliness. That was not the characteristic of the markets when I visited them in January and February.

The problem of greater space for the extension of their markets is pressing particularly upon the Cloth Market and Shiaganj. The former is solving it by extending into nearby streets. Shiaganj cannot do this, for its boundaries are fixed. Under such circumstances the movement always is for the erection of higher buildings, to secure in height the accommodation which is not available in land area. This movement has commenced in Shiaganj in one of two of the newer buildings. The Merchants generally, however, advocate an extension of the free zone. Is this desirable?

The figures which I have submitted in Part 2 show that the trade of Indore district is very largely a one town trade. It centres in Indore City. They further show that a very extensive trade is carried on not by Indore City merchants proper but by merchants in Shiaganj and the Residency, both of which are beyond the jurisdiction of the Sayar Department. The localization of trade here in Indore has peculiar disadvantages. When ever plague breaks out,—and it comes all too often—the shops in the City are practically closed. Shops in Shiaganj have been closed for months at a time. All trade in Indore stops. That of necessity means that the greater part of the trade of Indore District and of the Nimar also stops.

I take it, also, that the State cannot go back on its understanding with the merchants of Shiaganj and bring the free zone under the direct operation of the Sayar tariff. However, that is a step which does not seem to me to be necessary. The situation is different today from that it was 25 years ago. The export market for Indore's surplus food products is assured by the opening up of new trade routes and new markets. The cloth market and the city iron market have proven that markets within the city can maintain themselves.

Because of this I would recommend that Shiaganj be not enlarged; but that the policy of the State should be to ~~decentralize~~ decentralize the trade of Shiaganj and the Residency by building up new markets, possibly in Betma, Depalpur, Sipri, and Barwaha. If the first three were joined to Indore by light railways, with connections both to the railway go-down and to the city markets, the result would soon be the development of these markets. Temporary loans, or a preference in the tariff, would, I believe, result very shortly in the settlement of merchants in these places. Similarly Barwaha could be made the market centre for the Nimar by rail connection along the Nurbudda.

Such a re-adjustment would have obvious advantages to the State and to the people. It would prevent the complete demoralization of trade when plague breaks out in Indore. It would bring within the operation of the customs tariff much of the profitable trade with Dewas and Dhar and with the Nimar which is now centred in markets outside the direct control of the Commerce Department. The shorter cart haul would save oxen and labour, both of which could be utilized to great advantage in the agricultural development of the State.

Moreover such a development of markets throughout the State would have little adverse effect upon the markets

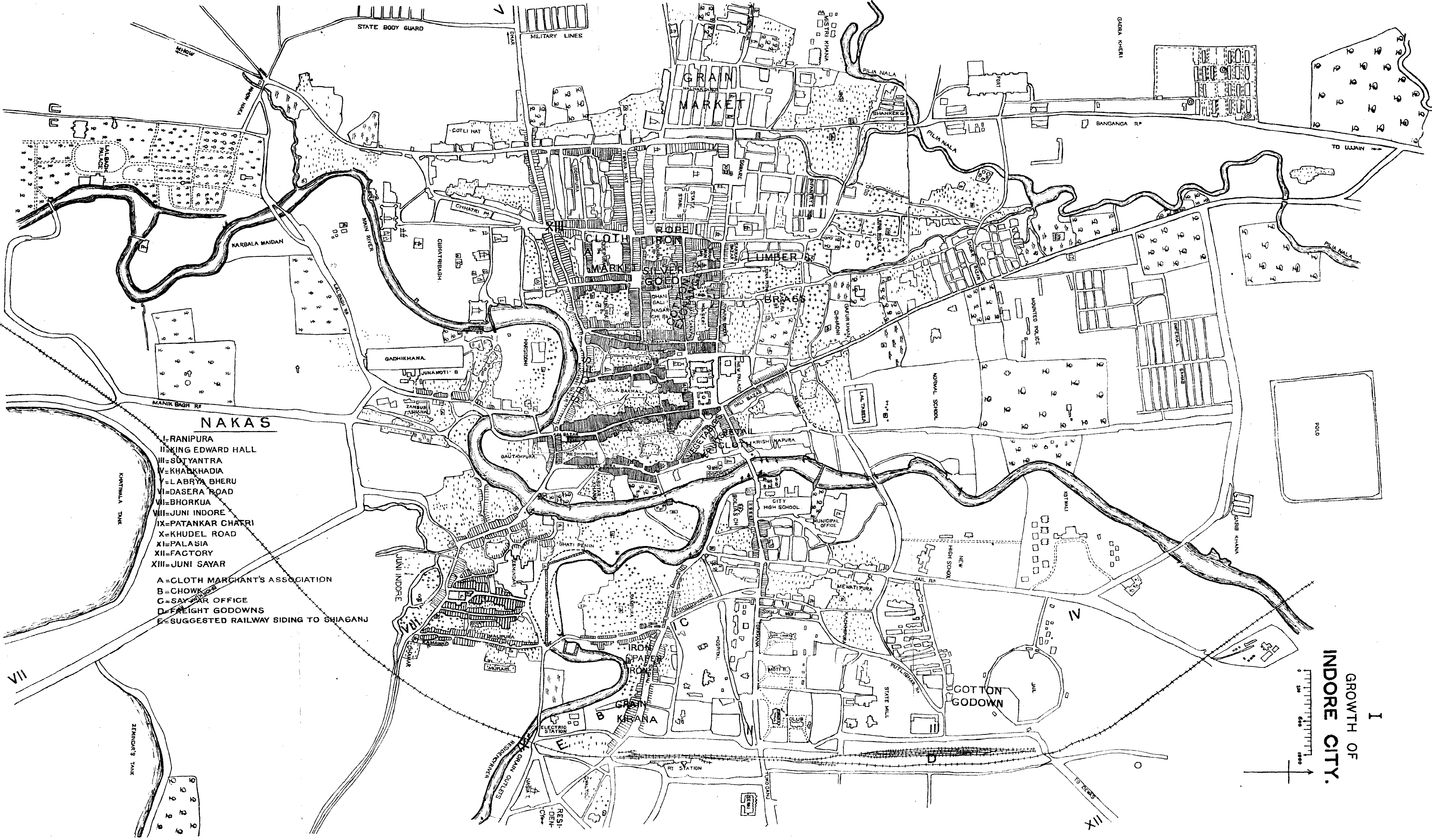
of the city proper,—lumber, cotton, brass, gold and silver, shoes, and the grain market of Malharganj. The latter has been confined more and more of late years to the trade of the city only, and it would be simply confirmed in that position. The other markets, depending more or less on industry, would not be adversely affected. Indeed as the City develops industrially, such lines would be found to render material assistance in the distribution of their products.

I believe that the policy of the Department in reference to the wholesale markets should be to develop these markets, as I have indicated, in various parts of the State. The opportunity to do so is now given when Shiaganj has out grown its borders.

Indore, April 8. 1919.

Harold W. Lyons.

I
GROWTH OF
INDORE CITY.



Zonal, District No. 1919--No. 273--283

RESIDENCY
GRAIN
KIRANA

**Bulletins of the Department of
COMMERCE AND INDUSTRY, INDORE STATE**

INDUSTRIAL SERIES NO. 2

B

P

**A Survey of
PRICES, COST OF LIVING AND WAGES
in Indore Bazaar**

By

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INDORE

1918.

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PREFACE

The writer wishes to express his thanks to Professor H. S. Jevons for his timely suggestions; and to Mr. K. A. Kelkar of the Indore Christian College for his valuable assistance in some of the investigations. The study is not in any way exhaustive, but is intended only as a preliminary survey of some aspects of the questions of prices, cost of living, and wages in Indore.

November, 1918.

H. W. Lyons.

An inquiry into the Course of Food Prices in INDORE RESIDENCY BAZAAR FROM 1902-1918.

India, together with all the world, is to-day passing through a period of high food prices. The percentage of increase over pre-war days has not yet become as high as in Europe and America. The Director of Statistics, Calcutta, has estimated that the rise in retail food prices at the end of March, 1918, over the pre-war level was 39 per cent in Karachi, 30 per cent in Bombay, 13 per cent in Calcutta. The Labor Gazette of the Minister of Labor, London, gives the rise in food prices in the United Kingdom by March 1, 1918; over pre-war days as 107 per cent; in Vienna by August, 1917, as 173.2 per cent; Norway by November, 1917, as 130 per cent; Paris by October, 1917, as 84 per cent; Canada by December, 1917 as 65 per cent; the United States by November 15, 1917, as 51 per cent; Australia by September, 1917, as 29.4 per cent. However, the comparative failure in many places in India of the last crops, profiteering by the banias, the large purchases on military account for the troops in India and Mesopotamia, the increasing scarcity of railway transport for civil supplies, have been leading to such a steady increase in prices during recent months that the Government have been compelled to appoint directors of civil supplies in order to avert, if possible, the worst dangers of the situation.

The following study of retail food prices and of the cost of living for several typical classes of people in the Residency Bazaar of Indore, has been made by the Economics Department of the Indore Christian College. It is of importance at the present time because (1) it is a study in a small bazaar of only 10,000 people, 400 miles from the nearest seaport, upon a single line of metre gauge railway, connecting at either end with the main lines of the G. I. P. and the

B. B. & C. I. railways, surrounded on all sides by native states upon whom it depends for much of its food supply; (2) it shows the course of prices from 1902-03, when the country had more or less returned to normal after the great famine of 1896-97; (3) it demonstrates clearly that the general tendency of prices and of cost of living for the past 16 years has been upward and that present prices are approaching, if indeed they have not passed, famine prices; (4) it suggests the inadequacy at the present time of the former customary wages, and (5) it points to the necessity of a study of food values in Indian foods and their substitutes, together with a development of gardening, and an advancement in agriculture and its methods

The figures upon which the tables are based are taken from the tri-weekly records of prices kept by the Bazaar Office. These prices are secured from the leading merchants in the Bazaar. Because of the proximity of the two Markets, the prices may be taken fairly to represent the prices in the Indore City Market for the same period. There is, of course, no guarantee that these are the prices actually charged to the people who live under a rupee a day, who form the vast majority of the population. Although the grain market is to-day fairly well organized, the bania seizes every opportunity of driving a separate bargain with his customer, ignoring the rest of the buyers in the market,—the chief characteristic of the Oriental bazaar. These recorded prices have been averaged for the four months from October 21 to February 20, partly to overcome the fluctuations which might occur within a few days or even weeks because of exceptional circumstances, and partly because the cold season, when trade is unrestricted by climatic conditions, forms a convenient basis for comparison of succeeding years.

Food Grains-Cereals

Wheat

The most important food grain consumed in Indore is wheat and it is the staple crop of the surrounding district.

The soil of Malwa is particularly suited to its cultivation, although, because of poor methods of cultivation, the average yield is only 6 maunds or 8 bushels per acre. In pre-war days considerable quantities of Malwa wheat were exported to Italy for the manufacture of macaroni. The main sources of supply for Indore are the Sipri valley, the Depalpur district, and the Dhar district. From the two former, and from other nearby districts it was found on investigation in the early part of May, 1918, that over 800 *manis* or almost 200 tons of wheat were brought into Indore city and residency by ox carts in a single day at that season. Malwi wheat is the most expensive wheat in India. The wheat sold in the Bazaar is usually Malwi mixed with Pissi or Nimari.

The course of prices with the percentage variations from 1902-03 to 1917-18 is as follows:—

Year	Price	Variation	Year	Price	Variation
	Rs. A. P.	per cent		Rs. A. P.	per cent
1902-03 ...	3 6 2	100	1910-11 ...	3 5 2	98
1903-04 ...	3 4 7	97	1911-12 ...	3 8 9	105
1904-05 ...	2 14 9	86	1912-13 ...	3 14 1	115
1905-06 ...	3 9 4	106	1913-14 ...	3 7 7	103
1906-07 ...	3 6 8	101	1914-15 ...	5 2 11	153
1907-08 ...	5 2 1	152	1915-16 ...	4 7 0	131
1908-09 ...	5 6 2	159	1916-17 ...	3 15 8	125
1909-10 ...	4 10 6	138	1917-18 ...	4 14 3	145

The increase of prices in 1905-06, in 1907-10, and in 1912-13 was chiefly due to the additional export of wheat to centres of crop failure. This is true of other food grains also. A further influence reflected in the general prices of the period 1907-10 was the severe financial crisis in the United States. The marked increase in wheat prices in 1917-1918 led the Government of Indore State to prohibit the export of wheat and of wheat flour from the State after January 23, 1918. At first this led to a rise of prices in the

Residency, which is politically separate although closely connected commercially with the city bazaar, because the rule was interpreted to prohibit exportation into the Residency. Since the Residency is surrounded on all sides by the State, the Residency practically had to depend on the stocks on hand, and upon the ordinary importation by road from neighboring states, until the matter was adjusted. The effect of the prohibition of exportation upon the retail prices of wheat is shown in Statement 1.

Wheat Flour

The course of prices of wheat flour, of which there has been an increasing consumption through the operation of the flour mills which have been opening on a small scale in the city, although thus far not in the Residency, was as follows:—

Year	<i>First quality</i>		<i>Second quality</i>	
	Price Rs. A. P.	Variation Per cent	Price Rs. A. P.	Variation Per cent
1902-03 ...	3 13 2	100	3 10 4	100
1903-04 ...	3 12 1	98	3 9 2	98
1904-05 ...	3 13 3	100	3 8 8	97
1905-06 ...	4 10 0	121	4 3 2	115
1906-07 ...	4 4 5	112	3 15 6	109
1907-08 ...	6 3 9	163	5 15 4	163
1908-09 ...	6 6 8	168	6 0 4	165
1909-10 ...	5 5 2	139	5 1 3	139
1910-11 ...	4 1 4	107	3 14 3	107
1911-12 ...	4 5 10	114	4 5 0	120
1912-13 ...	4 13 8	127	4 4 9	118
1913-14 ...	4 8 1	118	4 2 11	115
1914-15 ...	6 1 1	159	5 12 10	159
1915-16 ...	5 5 10	140	5 1 7	139
1916-17 ...	4 15 5	130	4 10 4	127
1917-18 ...	5 15 3	163	5 11 3	149

The percentage variations of wheat and wheat flour are shown in Chart A.

STATEMENT I.

RETAIL WHEAT PRICES

Indore Residency Bazaars.
Secr. & Chhataks per rupee

	JANUARY								FEBRUARY								MARCH							
	3	7	11	15	20	23	26	31	3	7	11	15	20	23	26	28	3	7	11	15	20	23	26	31
1918	8-8	8-4	8-4	7-12	7-8	7-12	7-4	7-4	7-8	7-8	7-8	7-8	7-12	7-12	7-12	7-12	7-12	7-12	8-0	8-4	8-8	8-8	8-12	8-12
1917	10-0	10-8	10-0	10-0	10-0	10-0	10-0	10-8	10-4	10-8	10-1	10-8	10-0	10-0	10-0	10-0	10-0	11-0	11-0	11-0	11-8	11-8	11-8	11-0
1916	8-12	8-12	8-0	8-0	8-0	8-4	8-4	8-0	8-8	9-0	9-8	9-8	9-8	9-8	9-8	9-8	9-8	9-12	10-0	11-0	11-0	10-8	11-0	11-0
1915	7-12	7-8	7-4	7-4	6-12	6-12	6-8	6-8	6-8	6-8	6-8	6-8	7-4	7-4	7-12	7-6	7-12	7-12	7-8	7-8	7-8	8-0	8-8	9-0
1914	11-11	11-4	11-9	11-11	11-4	11-0	11-3	11-6	11-0	10-15	10-15	10-15	11-0	10-15	11-0	11-0	10-15	11-0	10-11	10-9	10-8	10-4	10-3	10-1
1913	11-4	11-4	11-4	11-4	11-4	11-4	11-4	11-4	11-4	11-0	11-0	11-4	11-4	11-4	11-4	11-4	11-4	11-0	11-0	11-0	11-8	11-0	11-0	11-0

*Prohibition of export from Indore State from January 23, 1918.

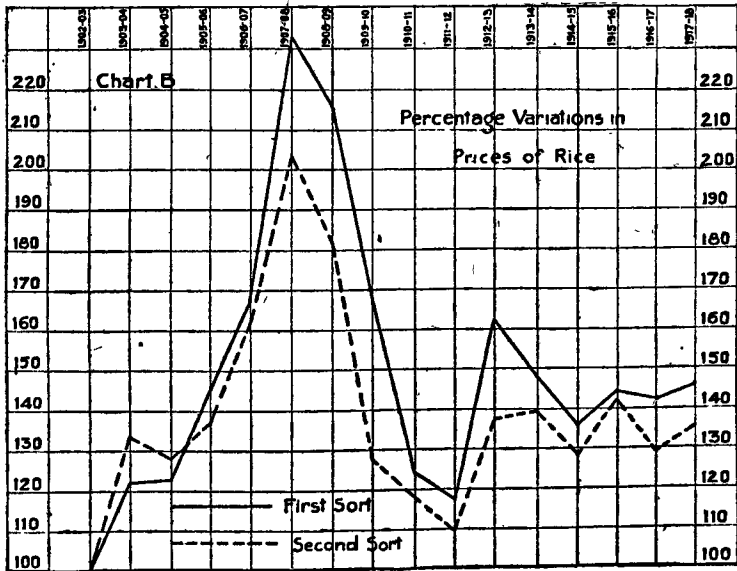
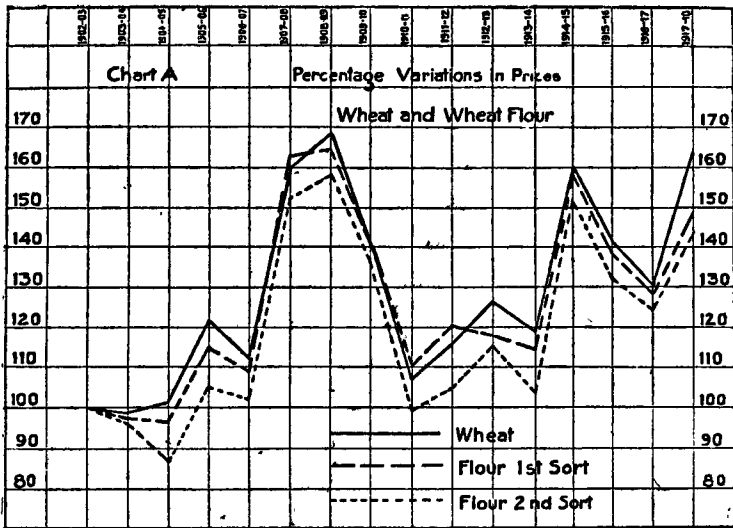
	JANUARY		FEBRUARY				MARCH			
	15-31		1-15		15-28		1-15		15-31	
	Secrs	Ch.	Secrs	Ch.	Secrs	Ch.	Secrs	Ch.	Secrs	Ch.
Indore City	7	9	7	0	7	8	8	0	8	8
Indore	7	7	7	8	7	12	8	4	8	12
Neemuch	8	12	8	12	8	8	8	8	8	6
Gwalior	7	4	7	4	7	4	7	8	8	0
Jabalpore	6	14	7	4	7	10	7	10	7	10
Nimar	7	1	6	12	6	12	7	0	7	5
Narsingpur	7	11	7	11	7	10	8	3	8	3
Akola	5	9	5	9	5	0	5	9	5	11
Jaipur	7	12	8	0	7	12	8	4	9	0
Allahabad	7	8	7	8	7	12	8	0	8	8

Rice

Rice is an imported crop. It is consumed to some extent ordinarily by better class people and by the better paid artizans. Nine varieties may normally be found on the market. Since the advent of exceptionally high prices for wheat in the spring of 1918, cheaper varieties of rice have become increasingly popular amongst the lower classes. The prices and variations during the period were as follows:—

Year	<i>First quality</i>		<i>Second quality</i>	
	Price	Variation	Price	Variation
	Rs. A. P.	Per cent	Rs. A. P.	Per cent
1902-03	4 4 3	100	3 15 3	100
1903-04	5 11 2	121	5 3 10	133
1904-05	5 11 5	122	5 0 0	127
1905-06	6 3 0	145	5 5 8	135
1906-07	7 2 3	167	6 5 6	161
1907-08	10 0 0	234	8 0 0	202
1908-09	9 2 5	215	7 1 11	180
1909-10	7 2 7	168	5 0 6	127
1910-11	5 4 10	124	4 11 2	119
1911-12	5 0 0	117	4 5 4	110
1912-13	6 15 6	163	5 7 0	138
1913-14	6 5 5	149	5 7 9	139
1914-15	5 12 8	136	5 0 0	127
1915-16	6 2 11	145	5 9 7	142
1916-17	6 1 9	143	5 1 1	128
1917-18	6 2 11	145	5 5 0	134

The percentage variations are shown in Chart B.



Food Grains and Pulses

Gram and Tur Dal

The variations in prices in gram and tur dal both of which are mainly local crops and the most important pulses, were as follows:—

Gram

Year	Price			Variation
	Rs.	A.	P.	Per cent
1902-03	2	9	0	100
1903-04	1	15	7	77
1904-05	2	1	6	82
1905-06	3	7	0	137
1906-07	3	1	3	120
1907-08	4	3	11	166
1908-09	4	7	7	175
1909-10	2	13	5	111
1910-11	2	3	8	87
1911-12	2	5	6	91
1912-13	2	12	6	109
1913-14	2	12	11	110
1914-15	4	6	11	173
1915-16	3	7	11	136
1916-17	3	8	5	133
1917-18	3	14	8	153

Tur Dal

Year	First quality		Variation	Second quality	
	Price	Variation		Price	Variation
	Rs. A. P.	Per cent	Rs. A. P.	Per cent	
1902-03	4 4 5	100	3 13 0	100	
1903-04	4 13 5	113	3 13 1	100	
1904-05	4 4 10	101	3 11 1	97	
1905-06	5 3 5	122	4 10 2	122	
1906-07	5 5 4	125	5 0 0	131	
1907-08	6 10 8	156	6 2 5	161	
1908-09	7 1 7	166	6 2 11	162	
1909-10	4 11 10	111	4 6 11	116	
1910-11	3 5 11	79	2 15 7	78	
1911-12	3 5 4	78	2 13 9	75	
1912-13	4 12 9	112	4 11 1	122	
1913-14	5 8 10	130	5 0 3	132	
1914-15	6 7 0	151	5 4 2	138	
1915-16	6 6 5	150	5 11 3	150	
1916-17	5 11 5	134	5 0 0	131	
1917-18	6 2 0	143	5 5 11	141	

The percentage variations are shown in Chart C.

Miscellaneous

Ground Nut

The variations in the prices of ground nut, which is altogether a local crop and for the improvement of which experiments have been made by the State Agricultural Farm, were as follows:—

Year	Price Rs. A. P.	Variation per cent	Year	Price Rs. A. P.	Variation per cent
1902-03 ...	4 7 10	100	1910-11 ...	4 5 11	97
1903-04 ...	4 9 11	90	1911-12 ...	6 10 8	148
1904-05 ...	3 15 10	89	1912-13 ...	5 15 9	133
1905-06 ...	4 11 3	105	1913-14 ...	5 9 9	125
1906-07 ...	5 9 10	125	1914-15 ...	4 15 1	110
1907-08 ...	6 6 0	142	1915-16 ...	4 15 1	110
1908-09 ...	4 12 2	106	1916-17 ...	5 0 5	120
1909-10 ...	4 11 2	105	1917-18 ...	6 10 4	148

Potatoes

Potatoes, which ordinarily are imported chiefly from the Fatehgarh district in the United Provinces, are not used by the poorest classes, and only sparingly by the artizan classes.

The prices and percentage variations were as follows:—

Year	Price Rs. A. P.	Variation per cent	Year	Price Rs. A. P.	Variation per cent
1902-03 ...	3 7 2	100	1910-11 ...	4 3 8	123
1903-04 ...	3 2 2	91	1911-12 ...	5 8 10	161
1904-05 ...	3 10 8	106	1912-13 ...	4 10 2	134
1905-06 ...	4 7 5	130	1913-14 ...	4 4 1	108
1906-07 ...	4 2 3	120	1914-15 ...	5 6 0	156
1907-08 ...	5 2 6	150	1915-16 ...	5 13 0	169
1908-09 ...	4 2 2	120	1916-17 ...	6 0 4	175
1909-10 ...	3 6 2	98	1917-18 ...	6 15 11	203

The general increase since the war is undoubtedly due to large purchases on military account for the increased number of British troops in India and Mesopotamia. The large increase in 1917-18 was caused by the additional difficulty in securing transport.

Sugar and Jagri.

Sugar ordinarily is imported from Calcutta, Cawnpore, Balia in the United Provinces and occasionally from Bombay. *Jagri* or *gur* comes partly from the surrounding villages, each of which has its field of sugar cane on irrigated land. Imported *jagri* comes principally from Barsi near Kolhapur in the Deccan, and from Lucknow and Barabanki in the United Provinces. The prices and percentage variations were as follows:—

Year.	Sugar		Jagri	
	Price Rs. A. P.	Variation per cent	Price Rs. A. P.	Variation per cent
1902-03 ...	8 1 11	100	4 15 4	100
1903-04 ...	9 2 7	113	5 12 11	117
1904-05 ...	10 10 3	131	6 1 5	123
1905-06 ...	9 2 0	112	6 5 5	128
1906-07 ...	8 10 0	106	7 0 8	142
1907-08 ...	8 14 2	110	7 3 2	145
1908-09 ...	9 8 8	118	7 1 4	143
1909-10 ...	10 0 0	123	7 8 1	151
1910-11 ...	9 3 9	114	7 1 5	143
1911-12 ...	11 9 5	143	7 15 3	160
1912-13 ...	10 10 0	123	7 3 9	146
1913-14 ...	8 11 3	114	6 10 0	134
1914-15 ...	12 9 11	155	6 8 7	132
1915-16 ...	14 8 8	179	7 15 1	160
1916-17 ...	16 15 5	209	8 10 6	175
1917-18 ...	15 5 9	189	8 11 10	176

Salt.

The prices of salt until the close of 1917 varied chiefly with variations in the salt tax, and with in-

creased production, influencing the consumption. The prices were:—

Year	Price	Variation	Year	Price	Variation
	Rs. A. P.	per cent		Rs. A. P.	per cent
1902-03 ...	3 11 6	100	1910-11 ...	2 0 0	54
1903-04 ...	3 6 3	91	1911-12 ...	2 5 8	63
1904-05 ...	3 6 0	91	1912-13 ...	2 4 1	61
1905-06 ...	2 10 0	71	1913-14 ...	2 3 3	59
1906-07 ...	2 10 4	71	1914-15 ...	2 3 7	60
1907-08 ...	2 2 8	57	1915-16 ...	2 4 4	61
1908-09 ...	2 1 2	56	1916-17 ...	2 7 10	67
1909-10 ...	2 1 6	56	1917-18 ...	3 6 10	92

The reduction of the tax in 1903 from Rs. 2-8 to Rs. 2 per maund resulted in a reduction of 5 annas in the selling price. In 1905 the further reduction of the tax to Rs. 1/8 per maund led to a fall in price of 12 annas. Was this due to increased production or to a considerable reduction in consumption because of food shortage? In 1907 the tax was again reduced by 8 annas fixing it at Re 1 per maund; and the selling price dropped 8 annas in 1907 and a further 2 annas by 1910. Increased consumption undoubtedly accounts for the slight increase until 1916; and the increase of 4 annas in the tax in that year to the increase in price in 1916-17.

The price of Rs. 3-6-10 per maund in 1917-18 does not accurately represent what occurred during those four months. From October to January the price increased rapidly until it reached the record average price for those months of Rs. 4-6-8 per maund, or a percentage variation of 118.5 as against 66.9 in the previous year. In January the Government supplied salt directly to the Bazaar authorities, who arranged

to sell it at 16 seers to the rupee, or Rs. 2-8-0 per maund, practically the price of the previous year. Later the price was reduced to Rs 2-5-8 per maund or 17 seer to the rupee. The fact that the Government was able to supply the salt promptly and that merchants were willing to sell at this price and that this increase in price was general throughout India and not confined to Indore, demonstrated that the abnormal prices were the result of flagrant profiteering on the part of operators who secured control of the market.

Chart D illustrates the percentage variation in prices.

General

The variations in the prices of Dry Grass, Milk, Firewood, Ghee, and Tea were as follows:—

Dry Grass

Year	Price		Variation
	Rs.	P.	
1902-03	0	7 9	100
1903-04	0	7 6	96
1904-05	0	11 0	142
1905-06	0	7 6	97
1906-07	0	10 0	129
1907-08	1	0 8	215
1908-09	0	8 1	104
1909-10	0	6 6	84
1910-11	0	10 0	129
1911-12	1	0 10	217
1912-13	1	0 4	211
1913-14	0	14 0	181
1914-15	0	14 2	183
1915-16	1	0 0	207
1916-17	0	15 10	204
1917-18	1	6 2	286

Milk

	Price			Variation
	Rs.	A.	P.	
1902-03	3	2	7	100
1903-04	3	9	4	113
1904-05	4	0	0	127
1905-06	4	0	0	127
1906-07	4	0	0	127
1907-08	4	0	0	127
1906-09	4	6	3	131
1909-10	3	15	10	126
1910-11	4	10	2	147
1911-12	4	7	7	141
1912-13	6	3	3	196
1913-14	6	6	4	203
1914-15	5	1	5	160
1915-16	5	0	0	158
1916-17	5	0	4	159
1917-18	5	0	0	158

Firewood

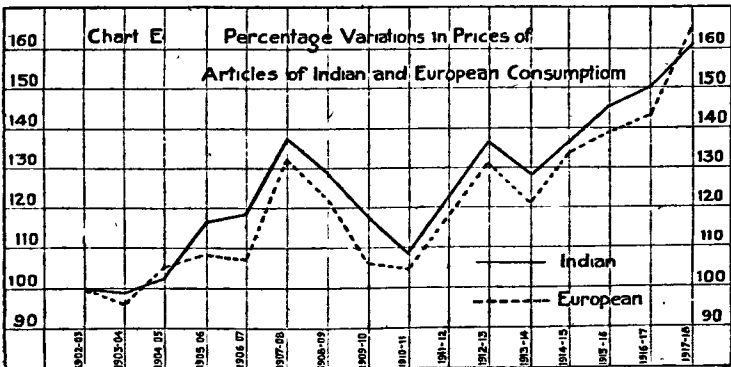
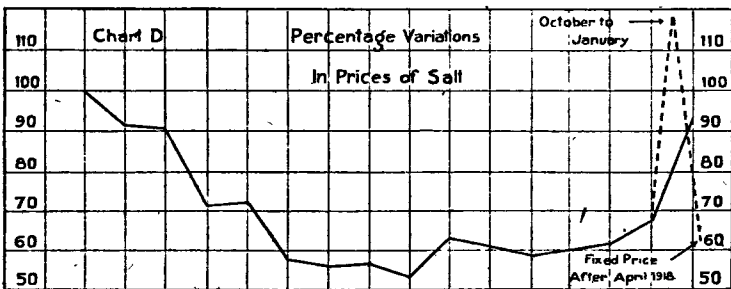
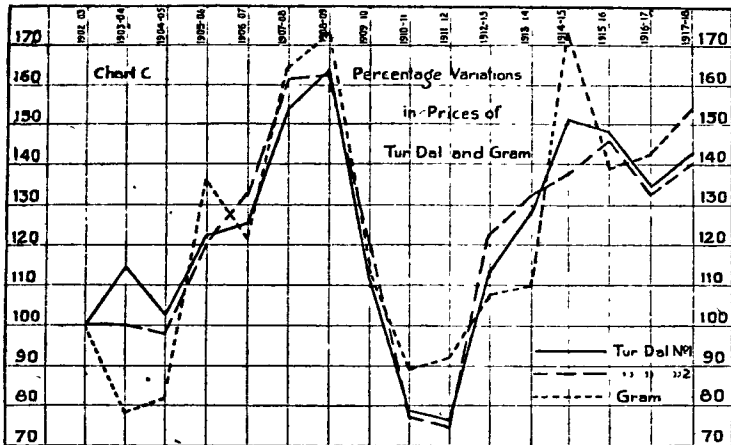
	Price			Variation
	Rs.	A.	P.	
1902-03	0	6	6	100
1903-04	0	6	1	94
1904-05	0	5	4	82½
1905-06	0	6	6	100
1906-07	0	5	6	85
1907-08	0	5	9	88
1906-09	0	6	8	103
1909-10	0	6	5	99
1910-11	0	6	5	99
1911-12	0	6	5	99
1912-13	0	6	5	99
1913-14	0	6	7	101½
1914-15	0	6	5	99
1915-16	0	6	5	99
1916-17	0	7	0	108
1917-18	0	11	7	178

Ghee Second Quality

Year	Price			Variation
	Rs.	A.	P.	
1902-03	24	6	0	100
1903-04	29	1	5	119
1904-05	31	9	11	130
1905-06	33	10	11	138
1906-07	35	13	2	147
1907-08	43	8	4	179
1908-09	33	4	2	136
1909-10	37	11	5	155
1910-11	38	4	10	157
1911-12	42	10	8	175
1912-13	52	4	11	214
1913-14	48	7	11	199
1914-15	37	2	0	152
1915-16	45	11	5	188
1916-17	52	12	9	217
1917-18	53	5	4	219

Tea

	Price			Variation
	Rs.	A.	P.	
1902-03	40	0	0	100
1903-04	40	0	0	100
1904-05	40	0	0	100
1905-06	40	0	0	100
1906-07	40	0	0	100
1907-08	44	6	6	111
1908-09	40	0	0	100
1909-10	40	0	0	100
1910-11	40	0	0	100
1911-12	40	0	0	100
1912-13	40	0	0	100
1913-14	42	1	6	105
1914-15	49	3	5	123
1915-16	74	5	4	186
1916-17	80	0	0	200
1917-18	80	0	0	200



The effect of the war is most noticeable in dry grass and tea, a great portion of both crops having been taken for military purposes. The great increase in the price of firewood is largely due to the substitution of wood for coal in some factories.

Price variations in articles of European and Indian consumption

The significance of the foregoing prices is seen when we consider the variations in prices of groups of articles of European and Indian consumption. Fourteen leading articles of European consumption are recorded in the Bazaar Office. They are: Wheat Flour, 1st sort; Rice, 1st sort; Wheat Bread; Salt; Tea; Milk; Sugar; Potatoes; Mutton; Beef; Eggs; and,—since most Europeans must keep a horse,—Gram and Dry Grass. Ten articles of common consumption by families of Indian artisans or laborers are given. They are: Wheat; Rice, 2nd sort; Tur Dal, 2nd sort; Ground Nut; Ghee, 2nd sort; Milk; Potatoes; Salt; Tea; Jagri.

The percentage variations in the total prices of each of these groups of articles seemed by something the prices of the individual commodities during the period are as follows:—

Year	European	Indian	Year	European	Indian
1902-03	100	100	1910-11	106	108
1903-04	98.5	100	1911-12	119	122
1904-05	104	103	1912-13	131	133
1905-06	109.6	116	1913-14	120	128
1906-07	108	118	1914-15	133	136
1907-08	133	139	1915-16	139	145
1908-09	122	129	1916-17	143	151
1909-10	108	117	1917-18	164	162

These variations are shown in Chart E.

The Cost of Living

An increase in the cost of wheat or of wheat bread, however, is more serious to the consumer than is an increase in

the cost of ghee or of tea. He consumes much more of the former, and he can obtain substitutes for or do without the latter. Consequently a study of variations in the cost of living, which considers the quantity of the demand for different commodities* by different classes of the community, is more important than a mere study of prices based upon uniform quantities.

An accurate study of the cost of living in different grades of society must involve the collection of budgets from a large number of families, from which average consumption may be determined. These budgets should include rent, fuel and lighting, clothing etc. as well as food. The figures given below are only for the articles of food indicated above, which, in the case of the Indian groups selected form the bulk of the purchased supplies. They were gathered during the course of this investigation by student investigators from not less than half a dozen families in each case, whose word could be relied upon; and the results were averaged. They are not, it is true, based upon a sufficient number of families to be accepted as absolutely accurate. However, in view of the fact that custom plays an important part even in food, and that people with small incomes have a greatly restricted choice, the figures may be taken as fairly indicative of the variations during the period.

Five classes of consumers have been considered: 1. a non-official European family; 2. a carpenter's family; 3. a mason's family; 4. an agricultural laborer's family; and 5. a syce's family. In each case the family includes a man, a woman, and one child of between 8 and 10 years of age. The quantities taken as the average monthly consumption in each case based upon the budgets secured, are :—

European Family

Potatoes 44 lbs; Sugar 20 lbs; Tea 2 lbs; Wheat 9 seer;
Bread 60 lbs; Rice 4 seers; Salt 2 seers; Beef 36 lbs; Mutton

4 lbs; Eggs 12 dozen; Milk 75 seers; Gram 60 seers; Grass 600 pindi; Firewood 10 maunds.

Indian Families

	Carpenter	Mason	Agricultural Labourer	Syca
Wheat	45 seers	40 seers	70 seers	50 seers.
Rice, 2nd sort	15 "	16 "	1 "	8 "
Tur Dal, 2nd sort	10 "	8 "	4 "	5 "
Ground Nut	1 "	1 "	0 "	0 "
Milk	10 "	8 "	0 "	0 "
Ghee	2 "	2 "	0 "	$\frac{1}{2}$ "
Gur	2.5 "	3 "	2 "	2 "
Potatoes	10 "	15 "	0 "	4 "
Tea	$\frac{1}{2}$ "	$\frac{1}{2}$ "	0 "	0 "
Salt	2 "	2 "	1 "	1 "

Based upon these figures of consumption the percentage variations in the cost of living in each case during the period are as follows:—

Year	European	Carpenter	Mason	Agricultural Labourer	Syca
1902-03	100	100	100	100	100
1903-04	129	107	106	95	103
1904-05	124	105	106	88	96
1905-06	144	129	119	107	113
1906-07	142	121	123	105	114
1907-08	169	158	159	151	156
1908-09	162	151	149	158	157
1909-10	144	129	127	135	123
1910-11	149	111	112	97	102
1911-12	165	120	124	105	110
1912-13	175	139	140	116	122
1913-14	172	132	132	105	114
1914-15	198	145	144	150	147
1915-16	185	146	149	132	136
1916-17	197	143	146	120	127
1917-18	204	159	162	145	149

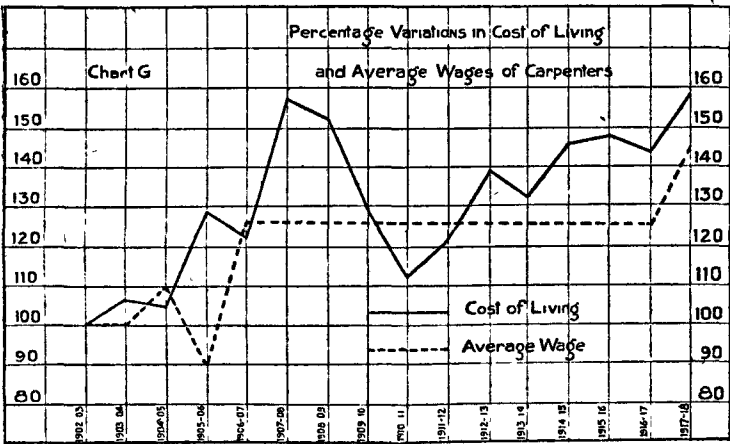
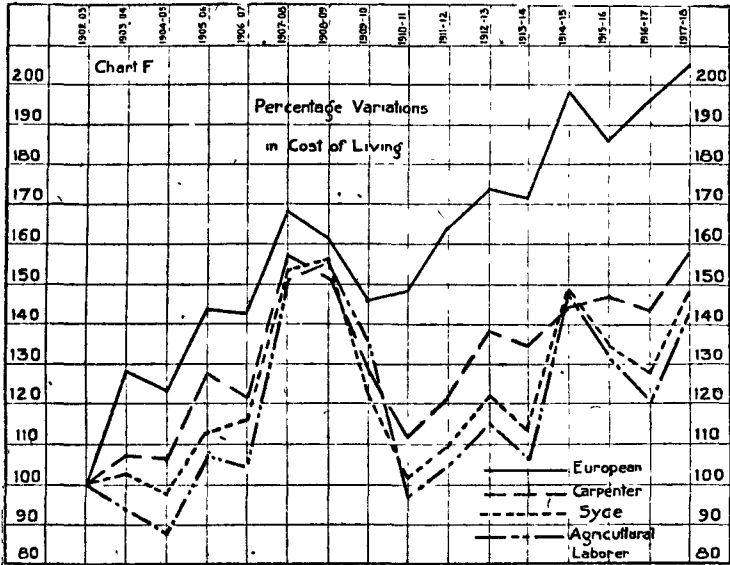
These variations are shown in Chart F.

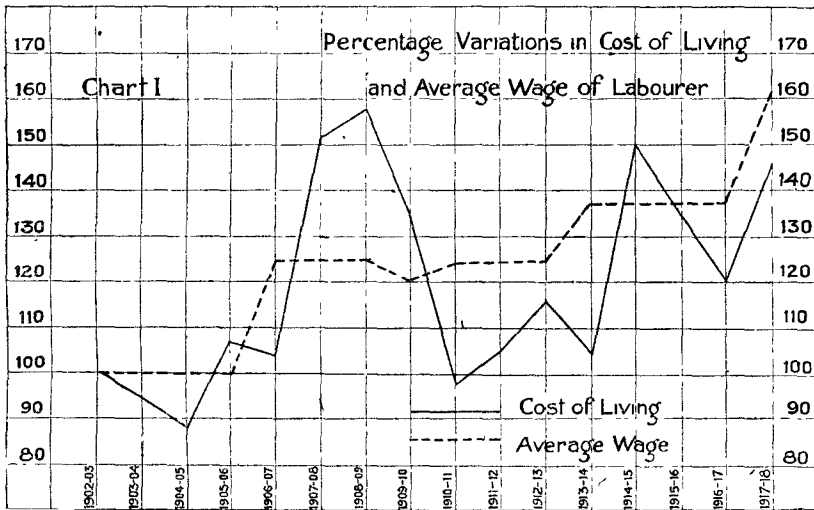
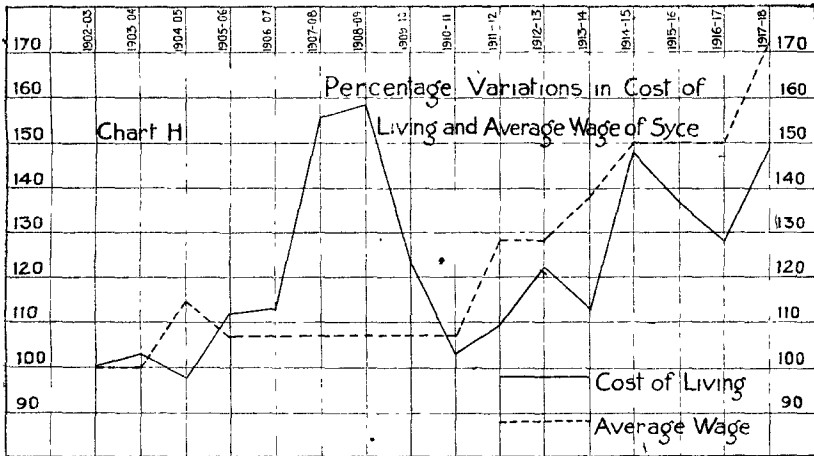
Wages

It is impossible to give the exact wages for the several groups of Indian workers for the period under consideration. The figures compiled by the Bazaar Office returned to the Government are for half yearly periods, and the monthly records were not available. The following table of percentage variations of the average wages is as accurate as it was possible to make it with the information at hand. Were records of wages kept in detail similar to records of prices it would greatly facilitate economic investigation. The percentages are based on wages in 1902-03 as follows: Agricultural Labourer Rs. 6.56 per month; Syce Rs. 5 to 6.5 per month; Mason, Carpenter and Blacksmith Rs. 15 to 17.81 per month.

Year	Agricultural Labour		Syce		Carpenter	
	Average wage		Average wage		Average wage	
	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent
1902-03	...	100	...	100	...	100
1903-04	...	"	...	"	...	"
1904-05	...	"	...	114	...	110
1905-06	...	"	...	107	...	90
1906-07	...	125	...	"	...	125
1907-08	...	"	...	"	...	"
1908-09	...	"	...	"	...	"
1909-10	...	120	...	"	...	"
1910-11	...	125	...	"	...	"
1911-12	...	"	...	128	...	"
1912-13	...	"	...	"	...	"
1913-14	...	138	...	136	...	"
1914-15	...	"	...	150	...	"
1915-16	...	"	...	"	...	"
1916-17	...	"	...	"	...	"
1917-18	...	163	...	171	...	145

Chart G, H and I illustrate the relation between wages and the cost of living for carpenters, syces and agricultural laborers. From the charts it would appear (1) that there





is no necessary connection between variations in the cost of living and variations in wages; (2) that those who must purchase all their food, and whose standard of living is higher—such as carpenters and masons—have been more seriously affected by increasing prices than syces and agricultural laborers, whose purchased food supply (consisting chiefly of wheat which is not a speculative crop with the banias) is smaller and less varied; (3) that the money wages of agricultural laborers have shown a remarkable increase, to be explained by a scarcity of labor due to the war rather than to a substitution of money payment for payment in kind.

General Conclusion

A comparison of the prices in Indore with those throughout India during the period demonstrates that prices here have followed in the main the general course of Indian prices. The first two years of the study belong to the period when internal Indian conditions were the principal factors in determining the price level. "Prices rose and fell, in the main, in accordance with changes in the agricultural conditions from year to year..... With the year 1905 Indian prices entered upon a new phase. Prices rose rapidly to unprecedented heights, and so far there is nothing to suggest a reversion to the level of former years. The explanation of this remarkable phenomenon cannot be found in changes of an internal nature; and an examination of statistics of prices in other countries indicates clearly that the increase in Indian prices has been broadly synchronous with a general upward movement in price levels throughout the world, and that its origin must accordingly be sought in causes more or less common to the whole civilized world."* Through the development of communications both internal and external, the decrease in the cost of transport, and the growth of banking and monetary facilities wider internal and external

* Resolution of the Government of India in the Finance Dept., Oct. 24, 1914, on an *Enquiry into the Rise of Prices in India*.

markets, especially for food stuffs, have developed. World influences have thus become more effective,—influences which have been distinguished by the Government investigator, Mr. Datta, as the increased supply of gold, the development of credit, the destruction of wealth in recent wars, and the expenditure on armament.

Undoubtedly high prices are here to stay, more especially of food articles of Indian production. Whether this will be to the advantage of the people as a whole will depend upon the percentage of the increased price which goes to the cultivators. Since he forms the largest numerical portion of the population, and since he is at the foundation of the Indian economic organization, every effort should be made to secure for him the largest possible share, not permitting the advantages of high prices to be completely absorbed by intermediaries. Such a policy which would give to the cultivator a surplus of capital is of social and national importance, since from it will come "better farming, better business, better living." Are any adequate steps being taken to protect the interests of the cultivators in this regard?

Quite apparent, also, is the fact that customary wages are no longer sufficient for workers in the larger villages and towns. If the present standard of living among such skilled workers as carpenters and masons, which is altogether too low, is not to be forced down lower still, wages must increase. A lowering of the standard of living would be disastrous to India industrially. It would plunge the Indian worker into the abyss from which the Western worker has been painfully struggling to climb; and it would at once condemn to failure any hope of continuous Indian industrial development. This is an aspect of the question which demands further study, and a liberal and sympathetic solution.

The facts as given point emphatically to the need for the immediate production here of food and yet more food. The possibilities of irrigation in and around Indore have not yet been exhausted. Indeed, why is it that the percentage of

irrigated land in the State has decreased within the last few years ? The Agricultural Farm has demonstrated that with wider furrows, shallower sowing and a change in the seed rate, the wheat crop can be greatly increased—and Malwi wheat is the best in India. The development of sewage farms* for the growing of vegetables upon the many patches of waste land in and around Indore, and the development and extension of the system of drying vegetables, open possibilities of great food wealth, which from the nature of the crop, would be entirely for local consumption. The facts of high prices, food shortage, increasing difficulties of rail transportation call for an energetic food production campaign both on the part of the Residency and of the State authorities.

*See Prof. Geddes Report on the Town Planning of Indore.

APPENDIX.

Since the completion of this survey the figures for the four months, October 21 to February 20, 1918-19, have become available. They show an alarming increase in prices and in the cost of living. Undoubtedly this has been largely due to famine conditions prevailing throughout India, reflected in the local market. Had not the export of food grains been prohibited by Indore State, and had not steps been taken by Government authorities to control supplies and prices in the Residency Bazaar, the situation would have been even more serious than it is. The facts of the present situation add additional force to the conclusions drawn in the report.

The variations in prices are as follows:—

No.	Article.	Index No 1918-19.	Variation from 1917-18.
1	Wheat	180.3	+ 35.8
2	Wheat Flour		
	(a) First	188.6	+ 39.4
	(b) Second	207.8	+ 44.5
3	Rice		
	(a) First	190.2	+ 45.7
	(b) Second	179.5	+ 45.1
4	Tur Dal		
	(a) First	229.7	+ 86.5
	(b) Second	210.7	+ 69.9
5	Gram	184.9	+ 32.
6	Ghee		
	(a) First	301.6	+ 81.2
	(b) Second	297.7	+ 78.9

No.	Article.	Index No. 1918-19.	Variation from 1917-18.
7	Wheat Bread	151.1	+31.8
8	Eggs	148.9	+41.6
9	Milk	220.1	+62
10	Jagri	201.7	+25.8
11	Sugar	184.4	-4.6
12	Potatoes	301.6	+98.7
13	Salt	66.	-26.2
14	Tea	200	...
15	Firewood	164.1	-14.1
16	Beef	100	...
17	Mutton	182.6	+43.5
18	Dry Grass	480.6	+194.6
19	Ground Nut	202.2	+54.2

The fourteen articles of European consumption taken in the report show an increase in price of 33.4 points, the index number being 197.4. The ten articles of Indian consumption show an increase of 44.5 points, the number being 206.

The variations in cost of living and of wages in the various groups are as follows:—

	Cost of living.		Wages.	
	1918-19	Variation from 1917-18	1918-19	Variation from 1917-18
European, non-official family	279.7	+75.3	...	...
Carpenters	203.8	+44.6	160	+15
Syces	191.2	+42.5	174	+ 3
Agricultural Laborer	180.9	+36.2	179	+16

No. 19.

**COMMERCE & INDUSTRY DEPARTMENT,
HOLKAR STATE.**

NOTE

ON

Sugar Manufacture

BY

SHAMBHOONATH,

EXCISE SECRETARY

**to the Minister in-charge Excise,
Commerce & Industry.**

1919.

INDORE.

Holkar State (Electric) Printing Press, Indore.

INTRODUCTION.

The people of India have been from times immemorial noted for their simplicity of life; and, as the fertility of the soil left them well provided for as far as their food was concerned, it was but natural that the *per capita* consumption of the article like sugar in the country should have remained low and that the people should have considered themselves above the anxiety for the knowledge of their material potentialities. Times have certainly changed and along with it ^{the} extent of our needs; the question of our natural development along material lines, however, has due to some reason or other been kept back, and that is the reason why we have to face this irony of fate in having to import even those articles of use in the production of which our country occupies practically the first rank, the article which we could have been able to feed the whole world with, had our resources been properly tended to before this.

China also has upto very recently followed a parallel path, but she has now been taking every pain to break loose from the fetters and it would be only our fault, if we wake up and realize that it is a "Now or Never proposition"—that we are up to a proposition which, if properly dealt with, will secure for us a place among the Industrial Nations of the world. That we *can* come up, has been proved by many glorious examples before us and we ought to be indebted to Mr. Shambhoonath, when he has taken so much pain in putting us up to the possibilities in the manufacture of sugar, the possibilities which are within our reach.

The figures given by Mr. Shambhoonath in his note are a good approximation which may have to undergo change in view of the "naughtiness" of the factors like location,

transportation and above all experimentations for the percentage of efficiency. Anyhow the undertaking is bound to be a realization which could be made to stand foreign competition, if the Agricultural Department succeeds in bringing about the desired improvements in the cultivation of SUGAR CANE, which will increase the production per acre and yield a better percentage of Sugar in it.

24th, June, 1919.

V. Y. Shewade, B. S., (ILL),
Chemical Engineer,
Indore State,

NOTE
ON
SUGAR MANUFACTURE
BY
SHAMBHOO NATH,
Excise Secretary

to the Minister of Excise, Commerce & Industry, Indore.

It is really very striking to note that there is not a single genuine Sugar Factory having up-to-date modern equipments for producing sugar direct from the canes and consequently India is looking to other countries for the supply of this important commodity.

Sugar is imported from:—

China, Germany (before war), Java, Cuba, the Straits Settlements and Mauritius.

The advantages regarding land, water, climatic conditions, labour and market which India enjoys testify with certainty that not only India can satisfy her own want but would be able to supply sugar to other countries too. But it seems that a wrong notion has been imbibed in the minds of people that India can never produce sugar commercially cheap enough to compete with her foreign competitors.

I cannot help quoting here the thought of the Emperor Marcus Aurelius Antoninus.

“If a thing is difficult to be accomplished by thyself, do not think that it is impossible for man but, if any thing is possible for man and conformable to his nature, think that this can be attained by thyself too”.

If a little consideration had been given to the problem, the question would have been solved long ago and India would have been the foremost country in the manufacture of sugar.

In view of the facts that India has a rich soil, cheap labour, favourable climate and sufficient water as compared to the foreign countries that stand prominent as the sugar producing countries, it is a pity that no attempts were made to find out the secret of success in the manufacture of sugar. One would say that India could not prepare machinery suitable to the manufacture of refined sugar, meant for commercial purposes. But surely she could import the machinery from sugar making countries which many people did, opened factories and failed within a very short time.

This would show that there must be a practical secret in the method of its manufacture.

The Preliminary fact which is open to all is the method of cultivation of canes. In foreign countries the yield per acre comes to 25,000 lbs. while in India the average comes to 6000 lbs. only. So the first and foremost question which should attract the attention is the scientific cultivation of canes. But even then the main secret remains which is as under.

It is a plain fact that the sugar industry is that sort of Industry the success of which entirely depends on the utilisation of its bye-products. Up till now it is understood that Alcohol is the only bye product which could be had, out of the crude residue of molasses which is obtained in the manufacture of sugar. But there is another very important bye-product of Alcohol which is quite unknown to the sugar manufacturers and that is the main cause why Indian sugar can not compete with that of the foreign manufacture.

There is only one factory in India at Sujapur (Punjab) which knows this secret (having engaged a German expert)

and carries on its trade successfully on the lines of the foreign manufacturers.

There are two reasons of this bye-product's being left unknown to the sugar manufacturers:—

- 1 (1) A wrong notion, regarding the technicality of fermentation.
- 2 (2) Their religiously guarding of the secret by the Sujapur Sugar Works.

Now here I will explain what this bye-product is and how it is profitably used.

During the course of fermentation the sugar of molasses decomposes into two constituents, viz :—Alcohol and CO₂ (Carbonic acid Gas). Up till now it has been the practice to collect the Alcohol only and let the gas escape in the air. The uses of this gas are numerous :

- (1) It is used in the manufacture of Aerated waters.
- (2) It is used in the manufacture of sugar as a purifying agent.
- (3) It is used as a cooling agent in ice manufacture and dairy farms for sterilising milk.
- (4) It can be used with great advantage in the manufacture of Fire Extinguisher.
- (5) It is used in chalk manufacture.
- (6) Liquid CO₂ is used by all the Hospitals of the Punjab for treating old and obstinate sores.

The average market rate of this gas is Rs. 56 per hundred lbs.

Hereafter it will be seen that the sugar manufacturers hitherto did not pay any attention to this bye-product which alone could have brought an income that could have lessened the price of sugar to a considerable extent.

Before explaining the above with facts and figures, I should like to mention a third bye-product which no one but the German manufacturers of sugar utilize. It is the culture of yeast from the liquid residue which is obtained, after the distillation is over. It is sold in the market by the name of Brewer's yeast and is used

- (1) By Distillers,
- (2) By Brewers,
- (3) By Bakers.

So to sum up the above, I would say that a sugar factory has the following products to sell in the market:—

- (1) Sugar,
- (2) Alcohol,
- (3) CO₂ (Carbon Dioxide),
- (4) Brewer's yeast.

From this it will be seen that the cost of sugar would be so small as to enable the Manufacturer to compete with the manufacturers of the remotest part of the world and the cost of the Alcohol would be so low, as to render it possible to be used for technical purposes and for the manufacture of Motor spirit, &c.

As I explained above much depends on the scientific cultivation of canes. So also I will mention here the fact that the success of sugar prepared out of other agents such as Beetroot, Palm, Dates, &c., depends on the method of their proper cultivation; for example, Beetroot cultivated in India does not possess so much percentage of sugar as the one grown in Germany and other countries.

I do not wish to enter here into the details of the cultivation owing to want of space and time. Moreover, this note is meant to explain the manufacturing side of the question. I leave the question of cultivation to the agricultural experts.

Upto now I have dealt with the question in general, but to be of practical utility I would now take the instance of Indore and suggest by means of facts and figures as to how we can have a nice little sugar factory that will supply our daily wants economically and increase the possibility of the development of trade.

To give a clear idea I would now give here all the possible approximate figures that I could gather:-

1. Yearly approximate consumption of *gur* in the State—!, 62, 006 maunds.
2. Yearly approximate consumption of sugar in State—79, 481 maunds.
3. Yearly local production of Gur in the State—18,951 maunds.
4. Yearly import of Gur in the State--1,44,175 maunds.
5. Yearly import of sugar in the State—86,322 maunds.

From the above figures it will be seen that there is a vast field for the success of a sugar factory and for the cultivation of the canes. But the latter can automatically increase, should the former be established on a sound footing.

The following details will give an idea of the total area which is under sugar cultivation in our State.

1. Indore District.....	1187	Acres.
2. Mahidpur District.....	214	,,
3. Rampura-Bhanpura District	304	,,
4. Nimar District.....	88	,,
5. Nimawar District	20	,,

Total, 1,813 Acres.

From the above figures it will be seen that the possibility of starting a sugar Factory exists only in the Indore

District and no where else. Taking this as our hypothesis, I deal with the figure of 1187 Acres. Out of this figure I would take off 87 acres production (canes) that will be utilised by the public for chewing alone.

The remaining 1100 acres will feed our sugar factory which will yield the following results.

1100 Acres at the rate of 70 maunds per acre will yield 77,000 maunds of Gur, which will yield 33,000 maunds of sugar and 22,000 maunds of molasses. These molasses will give 1,10,000 gallons of proof spirit and 4,40,000 lbs. of Co.

The yeast produced by the liquid residue will be about 200 maunds. *How? What basis or proportion?*

Now I will quote how much total gross income will it yield :—

Sugar at Rs.	10	per maund.....	Rs. 3,30,000
Spirit at Re.	1	per gallon L. P.....	Rs. 1,10,000
Co, at Rs.	56	per 100 lbs.....	Rs. 2,46,400
Yeast at Re.	1	per lb.....	Rs. 16,000
Total			Rs. 7,02,400

It would not be out of place to mention here that this whole out-turn will be got by the working of the Factory for 6 months only during the whole year and in the remaining six months the factory will prepare sugar out of imported Gur or spirit out of imported molasses. The Sujapur Factory manufactures the latter stuff.

The cost of initial expenditure will not be more than Rs. 6 lakhs and a working capital of Rs. 2,00,000 will suffice.

The yearly expenditure will not exceed Rs. 2,00,000, therefore, the net income will be Rs. 5,02,400 as detailed in the enclosed chart.

Shambhoo Nath,
Excise Secretary.

APPENDIX, A.

Cultivation of Cane.

1100 Acres.		
Gur 77,000 Mds.		
Sugar. 33,000 Mds. Rs. 3,30,000.		
Molasses. 22,000 Mds.		
Spirit. Proof Gall. 1,10,000 Rs. 1,10,000.	Yeast. 200 Mds. 16,000.	Co 2. 2,40,000. 2,46,000.
Total Gross income. Rs. 7,02,400		

Initial Expenditure	...	...	Rs. 6,00,000.
Working Capital	...	...	,, 2,00,000.
Therefore, net Profit	...	...	,, 5,02,400.

APPENDIX, B.

Details of Expenditure for the Sugar Factory.

Building!	...	...	Rs. 1,50,000
Sugar plant	...	...	Rs. 1,00,000
Alcohol plant	...	...	Rs. 1,50,000
CO ₂ plant	...	...	Rs. 75,000
Yeast	...	...	Rs. 25,000
Laboratory	...	...	Rs. 25,000
Unforeseens	...	...	Rs. 75,000
Total,			Rs. 6,00,000

APPENDIX, C.

Addresses of some of the Firms who deal in suga
producing machinery and equipments.

1. W. & T. Avery, Ltd. Automatic
Dept , (A), Soho Foundry,
Birmingham.
2. George Fletcher & Co , Ltd , Derby,
England.
3. Blair, Campbell & McLean, Ltd.,
Wood Ville Street, Govan,
Glasgow.
4. Fawcett, Preston & Co., Ltd.,
Liverpool.
5. Hersey Manufacturing Co ,
Sole Makers,
South Boston Mass,
U. S. A.
6. Cotton, Nell & Co, Ltd.,
82, Wall Street,
New York, N. Y.
7. Aitken & Co,
Sugar Machinery Specialists,
147, Bath Street,
Glasgow.
8. John McNeil & Co., Ltd.,
Colonial Iron Works, Govan,
Glasgow.
9. The Sugar Manufacturing Co., Ltd.,
Head Office, 76, Elsham Road,
London, W. 14

Dr. Shaw's works

Authorities

- (1) Note written by him on
Dye - production & endorsed
by Dr. Fowler
- (2) Works concerning of his part
of India
- (3) Muhammad Hadi's note on
the ^{cause} of malaria
- (4) His personal visit to Hyderabad
- (5) Statements supplied by Dr. R.
- (6) 10 years experience of Ferozabad
& Dibrugarh
- (7) Research at Bangalore in the
Tumor Institute of India

APPENDIX, C.

Addresses of some of the Firms who deal in sugar producing machinery and equipments.

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Dept, (A), Soho Foundry,
Birmingham.
2. George Fletcher & Co, Ltd, Derby,
England.
3. Blair, Campbell & McLean, Ltd.,
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Sugar Machinery Specialists,
147, Bath Street,
Glasgow.
- 8 John McNeil & Co., Ltd.,
Colonial Iron Works, Govan,
Glasgow.
9. The Sugar Manufacturing Co., Ltd.,
Head Office, 76, Elsham Road,
London, W. 14.

Dr. Shanu Bhowmik

Authorities

- (1) Note written by him on
Boys - production & increased
by Dr. Fowler
- (2) Notes summary of his papers
of India
- (3) Muhammad Hadi's note on
Cultivation
of *Agave*
- (4) His personal visit to Hyderabad
- (5) Stationing applied by L. R. &
D. R.
- (6) 10 years experience of Formulation
& Distillation
- (7) Research at Bangalore in the
Indian Institute of Science

Department of Agriculture, Bombay.

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BULLETIN No. 106 OF 1920.

DHARWAR AMERICAN COTTON.

ITS HISTORY CULTIVATION AND
IMPROVEMENT.

BY

G. L. KOTTUR, B.Ae,
COTTON SUPERVISOR, S.D., DHARWAR.



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DHARWAR AMERICAN COTTON.
ITS HISTORY, CULTIVATION AND
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DHARWAR AMERICAN COTTON.

Its history, cultivation and improvement.

I. HISTORY.

The origin of cotton cultivation in *Karnatak* is obscure. At any rate we find that cotton growing and cotton manufacturing were well established in *Karnatak* long before its occupation by the British. Two varieties were then growing, one *Dev-Kapas* *G. arboreum* a tree cotton sparingly planted in gardens and temples near wells and another *Javari-hatti* (local cotton) *G. herbaceum* an annual largely cultivated in black soil fields without irrigation. The kapas of the former was handginned and the cotton used in making sacred threads and lamp wicks. *Javari-hatti* was ginned on the so called foot roller gin, the simplest and probably the first form of a gin invented in this country. It consisted of a flat rectangular piece of stone, an iron roller and two small pieces of split bamboo, all completely detached and separate. The roller was placed on the stone and held at the ends on the two pieces of bamboo by the feet. The ginning was done by the movements of the feet, the hands of the operator, always a woman, doing the feeding. The operation though clumsy and laborious, as it seems, was by no means costly. One woman working for 7 hours ginned 28lbs. of kapas on an average per day costing 2 annas or even less. The cotton thus ginned was almost entirely consumed in the local hand mills a number of which were steadily working in every village.

The product of these hand mills not only clothed the people of *Karnatak* but also went out to supply the foreign demand. It might have even reached Great Britain during the first half of the 18th century when that country was importing a large quantity of yarn and clothes from India. This import had kept the spinning of England almost stationary for a long period. Under these circumstances the demand of Great Britain for raw material continued to be small and the quantity of cotton received from all sources during the first half of the 18th century did not exceed an average of 4,000 bales, a considerable part of which was used for candle wicks. But things took a different turn in the other half of the same century. The inventions of Hargreaves Arkwright and Watt laid the foundation of the

world wide industry, and as a result England began to consume considerable quantities of cotton in her mills. Her imports of raw cotton amounted to in the year 1800 about 112,000 bales.

India was the only exporter of raw cotton to England for a long period but the first American shipment was made from Charleston in 1747 which consisted only of 7 bales. In 1784, 14 bales were again shipped to England but these were seized in Liverpool as contraband. American exports in any quantity however arrived in England for the first time in the year 1791 when 378 bales were received. In 1793 Eli Whitney invented his saw gin and the effect of this invention on the export trade was so quick that America was able to ship 3,200 bales in the very following year. Since then American cotton entered English markets in increasing quantities and acquired its supremacy over Indian. In 1811, America exported 93,500 bales while India exported only 10,252 bales, the proportion roughly being 9 to 1.

These large imports of American Cotton naturally came in the way of Indian trade. But England was always doubtful of a regular supply from America. The Non-Intercourse Act passed by the United States in 1809 strengthened the doubt and showed the urgency of procuring the supply of raw material from sources other than America. At this time, a cry was also raised by the English Mills against the inferior quality of Indian staple. In 1809 the Court anticipating deficient supplies from America ordered all private ships to bring cotton from India and 60,000 bales were thus imported. But in the following year, the Court wrote that more than 50,000 bales of Indian Cotton still remained unsold in their warehouses for two reasons the renewed intercourse with America and the coarse nature of the Indian Cotton. In 1811 the American supply was large and regular, and the Court then wrote that Indian Cotton remained a ruinous and unproductive burden both upon Company and the private importers. They therefore ordered that no cotton should be shipped from India to England on their account. They also urged upon the Indian Government in the strongest manner the absolute necessity of securing greater cleanliness of the cotton and the desirability of introducing finer kinds for improving the quality.

At this epoch Bombay Karnatak passed from the hands of the Peshvas to the British in the year 1818. The importance of these new possessions for cotton was at once recognised and in the following year, the Commercial Resident in the ceded districts recommended the distribution of Brazilian, New Orleans and Sea Island cotton seed in Dharwar. Regular experiments were however undertaken under orders from the Court of Directors to improve the local cotton and introduce fine foreign varieties in the year 1829, and one Dr. Lush was appointed to conduct these. Dr. Lush opened a Cotton Farm at Shighihalli a village in Khanapur Taluka of Belgaum District and made trial sowings of American seed in Navalgund, Dharwar and Morab all in Dharwar District. The Shighihalli Farm was run from 1830 to 1836 during which the following varieties were tested with little success :—

- | | |
|--------------------|----------------|
| 1. Georgian | 5. Louisiana. |
| 2. Sea Island | 6. Pernambuco. |
| 3. Upland Georgian | 7. Bourbon. |
| 4. New Orleans | 8. Egyptian. |

The results of trials made in Navalgund and other places were various and of doubtful value. The first series of Dharwar Experiments were therefore closed in the year 1836 they being considered to have failed after a fair trial.

The growing necessities of Great Britain for raw material forced the several commercial bodies in 1838 to send an urgent memorial to the Court of Directors praying them to devise and adopt measures to improve the quality and extend the cultivation of Indian cotton. The Court of Directors thereupon secured the services of 12 American planters to carry out this work, three of whom were allotted to Bombay Presidency where they arrived in the year 1840. But all the three planters proceeded to Broach where it was decided to make the first experiments. In the meantime Mr. A. N. Shaw, the then Collector of Dharwar, obtained permission from the Court of Directors to try New Orleans Cotton in Dharwar and sowed 10 acres near Hubli under the Local System of cultivation. This was done in the month of August 1842. The crop grew well and its superiority over the local cotton was admitted by the cultivators and merchants who saw it. At this time Mr. Mercer an

American planter transferred from N. W. Provinces visited the New Orleans crop at Hubli, and reported very favourably about it. The results of this trial are given below :—

Area As. Gs.	Names.	Yield per acre.		Ginning %	Remarks.
		Kapas. Lbs.	Lint. Lbs.		
10 0	New Orleans ...	286	88	33.3	
10 0	Local (Kumpta) ...	196	44	24.2	

The experiment was thus a great success probably for two reasons, the location of the plot in the area better suited to grow American Cottons and the proper time of sowing. Being encouraged by these results, Mr. Mercer was appointed at the suggestions of Mr. Shaw to whom the credit of having successfully introduced the American Cotton in our part is due, to superintend the cotton experiments in Dharwar. This was done in the year 1843 when Mr. Mercer took an experimental farm at Kusugal in Hubli Taluka where he planted 183 acres with 6 varieties of cottons. In the same year Mr. Shaw recommended the local cultivators to grow New Orleans Cotton, and as a response to his recommendations, 362 acres were sown by the *rayats*.

The results of the first year's experiments on the Government Farm at Kusugal were in favour of New Orleans and Broach to which Mr. Mercer recommended the future experiments to be principally confined. New Orleans also gave better yield in the field of cultivators. It produced 48lbs. of clean cotton per acre on an average, and taking the yield of local cotton (Kumpta) on very superior land as 30lbs., New Orleans yielded 18 lbs. of clean cotton more per acre. The whole produce of the Government Farm and the New Orleans crop of the cultivators were ginned on Sawgins five of which were procured from Broach and Coimbatore with great difficulty for the purpose.

In 1844 the area under New Orleans extended to 2,749 acres and a second farm was also started to conduct cotton experiments at Gadag under the care of Mr. Hawley. The crop on the Kusugal Farm was attacked by insect pests and the yields were consequently poor. The prospects of the Gadag Farm however were very high. Both the New

Orleans and Broach cottons yielded heavily. The run of the cultivators' crop was also larger and healthier. In 1845 it was decided to abolish the two Government farms they being no longer requisite, but the planters were allowed to contract with rayats for the cultivation of New Orleans cotton under their direction. The area under New Orleans increased to 11,176 acres and the Collector reported that the crop flourished very vigorously wherever the season was favourable. In the following year the contract system was also discontinued and the increasing cultivation was left wholly in the hands of the cultivators with a pledge on the part of the Government to purchase the crop if necessary. The crop now occupied an extensive area of 22,331 acres in the District.

The efforts to introduce the cultivation of New Orleans Cotton in the Dharwar District were thus singularly successful. The area under the cotton went on steadily increasing and in 1861 we had 178,682 acres of New Orleans an area almost equal to that under local cotton. The quality of this cotton was also satisfactory. In 1847 Messrs. G. S. King & Co. furnished the following report on the two samples of cotton Dharwar New Orleans or Sawginned Dharwar and Kumpta which had been tested by Lancashire spinners.

Dharwar New Orleans:—'It is reported as of good staple and colour very clean the staple not injured by the ginning. It was valued at 6½d. per lb. when the best Surat was selling in Liverpool at 5¾d. per lb. and the American qualities from middling to fair were selling at 4¼d. per lb. Our friends say that it is unexceptionable in every respect. In the spinning tests the Ordinary New Orleans (American) lost 17½ per cent. while the Dharwar New Orleans lost only 15 per cent.; the yarn being quite equal.' The Kumpta cotton sent along with New Orleans was reported as under:—

'We find the Sawginned Kumpta full of small broken fragments of leaf. This is the glaring defect of it. The cotton is full of an infinity of minute particles all adhering most pertinaciously to the cotton so that it is utterly impossible to eject them. This is most unfortunate as the cotton itself is about the best specimen of East Indian Cotton we ever worked. In the carding and spinning it has given unqualified satisfaction but all these qualities are

rendered null by the impossibilities of eradicating the small leaf dirt from the yarn which exhibits so many specks of dirt as to be almost unsaleable.'

In 1850 Government resolved to discontinue their purchases of cotton as the exotic had firmly established its popularity. The experimental establishment was then reduced and its operations confined to the business of the gin factory first under the charge of Mr. Frost an Engineer and then under the superintendence of Dr. Forbes. At this time Messrs. A. C. Brice & Co. established an agency in the Dharwar District for ginning and purchasing the cotton which materially assisted the development of the improved Dharwar cultivation. The following table gives the areas under Dharwar American and Kumpta cottons for a period of 40 years from 1842 to 1882:—

Year.	Acreage.	
	Under Dharwar American.	Under Kumpta.
1842	27	184,237
1843	545	178,411
1844	2,749	182,437
1845	11,176	164,591
1846	22,331	167,592
1847	20,502	179,229
	Average of five years.	
1848-1852	24,249	224,673
1853-1857	82,060	222,978
1858-1862	216,909	217,533
1863-1867	294,159	178,456
1868-1872	317,780	226,729
1873-1877	191,640	219,854
1878-1882	149,844	354,892

II. CULTIVATION.

The new Orleans Cotton thus introduced and acclimated in Dharwar is called Dharwar American or Sawginned Dharwar. It is locally known under various names of which *Vilayati-hatti* (English Cotton), *Farangi-hatti* (foreign cotton) *Dodda-hatti* (big seeded cotton) are the most common. Its cultivation is practically confined to a small tract in Bombay Karnatak comprising all the 11 talukas of Dharwar, the southern talukas of Bijapur, the Native States possessions of Kundgol, Savasi, Gudgeri, Lakshmesbvar, Shirahatti and Savanur. It further extends into Nizam's Dominions, Madras Presidency and Mysore State but the extension is very limited. This tract which is more suited for Dharwar American Cotton grows the latter but not exclusively. It also grows Kumpta cotton more or less.

The following table gives the areas under Dharwar American and Kumpta in the British portion of the Bombay Karnatak during 1918:—

District.	Taluka.	Area during 1918.		Total.
		Dharwar American.	Kumpta.	
Dharwar.	Navalgund	22,215	99,063	
	Gadag	74,003	60,234	
	Dharwar		36,543	
	Bankapur	16,706	30,218	
	Kalghatgi		11,006	
	Ron	43,502	49,125	
	Hangal	1,837	10,250	
	Karjigi	20,926	55,120	
	Kod	8,280	12,203	
	Ranebennur	40,907	14,856	
	Hubli	32,826	24,725	
	Total	261,232	403,343	664,575

District.	Taluka.	Area during 1918.		Total
		Dharwar American.	Kumpta.	
<i>Belgaum.</i>	Athani		41,293	
	Khanapur		86	
	Gokak		37,879	
	Belgaum		4,727	
	Chikodi		11,843	
	Sampagaon		28,087	
	Parasgad		75,826	
	Huckeri		9,046	
	Murgod		22,320	
	Total		231,107	231,107
<i>Bijapur.</i>	Badami		38,165	
	Bagevadi	10,000	75,393	
	Indi	32,809	77,129	
	Muddebihal	32,897	49,346	
	Bagalkot		95,825	
	Bijapur		64,255	
	Sindgi		70,000	
		Total	75,706	522,299	602,005

Cotton is generally a Kharif crop being sown at the commencement of the rains. But in Karnatak the early sown crop often suffers from the north-east showers falling in the months of October and November. By experience therefore the cultivators have found that the sowing time for

cotton is between August and October the critical date varying according to the kind of cotton and locality. All cotton in Karnatak is thus Rabi but there is a small area in Dharwar District especially in Ranebennur Taluka where the Dharwar American Cotton is Kharif as well as Rabi. We have accordingly two different methods of cultivation to deal with.

A. *Kharif or Mungari Cultivation.*

This is done in the two Talukas of Ranebennur and Haveri of Dharwar and the adjoining Talukas of Chitaldurg and Bellary Districts. The area which is comparatively small and for which separate figures are not available, varies much according to the nature of the season. It swells in years when the early rains of June are favourable and shrinks when they are not. Red soils of all descriptions are suited for Kharif cultivation of Dharwar American Cotton whose success is mainly due to the well drained condition of all such soils and to the moderate character of the Rabi rains. The land is prepared by country ploughing and harrowing. Sabul plough of Messrs. Ransomes Sims & Co. is recommended for ploughing all red soils and its use is extending. Manuring is generally done, the quantity varying from 1 to 5 tons per acre. The seed is sown soon after the early rains break out in June. The sowing as in all cases of cotton is done through bamboo tubes behind the drill. The seed rate is 14 to 21 lbs. per acre purposely heavy to minimise the effects of chopping which always occurs on hard red soils while interculturing. The distance between the rows varies from 18-24 inches and that between the plants in the rows is indefinite. After-cultivation consists in a number of inter-culturings 6 to 12 given during the breaks of rain. The flowering commences generally in September and the first picking is gathered in November. If the Rabi rains of September and October fail, the pickings are over by January but if they fall they induce second flowering which starts in December and the plants go on bearing cotton till the end of April. Sometimes the Rabi rains instead of being moderate are heavy in which case the first formed buds, flowers and bolls all shed and the crop ripens late in the same way as the Rabi. All these have considerable influence on yield which is moderate in the first case, very good in the second and poor in the last. A very good yield exceeds 1,000 lbs.

of Kapas per acre, a moderate one gives 400 to 600 lbs. while a poor one only 200 to 300 lbs. of Kapas per acre.

The Kharif crop of Dharwar American Cotton is liable to the severe attack of red leaf blight and this is one of the reasons why its cultivation is not extending in other talukas though they possess considerable area of red soil quite suited for it. At Ranebennur the cultivators have unconsciously eliminated the susceptible types from their variety by using the same seed over and over again. Now we have obtained by selection a pure strain of Dharwar American named Gadag I, which resists the red leaf blight, we hope to succeed in spreading its cultivation on the red soils outside the present tract with some modification in the time of sowing. Many such soils are unprofitably cropped continuously with Jowar or Jowar in rotation with such inferior crops as Kulthi and Niger seed. If cotton is made to grow on them it will be the most profitable crop for them and at the same time the best rotation for Jowar.

B. Rabi or Hingari Cultivation.

This is done in the whole of the Dharwar American tract on black or reddish black soils which are generally deep and retentive. The land is prepared by country ploughing and two or three harrowings. The ploughing is done when the land is softened by one or two good showers in May or June. Rabi cotton is not manured as a rule. The previous crop of Jowar gets the manure and cotton takes the advantage of the residual effect. But the practice of putting manure directly to cotton is common among cultivators who continuously grow cotton on the same land. Sowing is done in the months of September and October. The seed is first rubbed with water cowdung and earth in order to cement the fuzz which if left loose clogs the tubes. It is then sown through bamboo tubes behind a two coultered drill. The seed rate is about 7 lbs per acre. The distance between the rows is 21 to 24 inches. The mixtures in Dharwar American Cotton are less common than in Kumpta. It is sown either alone or mixed with a small quantity of Rabi Jowar or *gidgempu* which is cut when in flower for fodder. Kharif Jowar and Cotton is the most common rotation. Wheat and cotton is not uncommon. A three course rotation of cotton wheat and Jowar is in favour with some cultivators. Rabi Jowar and Cotton is also practised to some extent. But

cotton as a rule does not do well after Rabi Jowar. There are, however, some fields in Gadag and Ron Talukas which know no rotation for 20 years or more.

The crop is intercultured 2 to 4 times. It flowers in November-December and is ready for the first picking in February-March. The seed cotton is gathered in 2 or 3 pickings the last being over by the end of April. Yield varies according to soil season and treatment from 200 to 600 lbs. of Kapas per acre. The picking is done as carelessly as in the case of Kumpta, but the cotton is much cleaner because the leaves and bractioles of Dharwar American plants do not dry up, to be easily mixed with the pickings. The produce is then sold as seed cotton which is by far the most common method or is first ginned in one of the local saw gins and the lint sold. The second is no doubt the more profitable method as the owners get in that case the full benefit of their ginning outturn. Seed cotton and lint both are handled in gunnies which when well filled hold about 350 lbs. of Kapas or 150 lbs. of lint.

The Rabi crop of Dharwar American Cotton has also certain risks to run. In some years the rains of September and October fall continuously in torrents soon after the sowing in which case the crop makes little progress and yields poorly. It also suffers occasionally from the attack of Aphis and often from red leaf blight. The former appears in October or November and continues during the whole of the flowering period. It causes the flowers to shed in large numbers and the yield consequently suffers much. Red leaf blight as the name indicates makes the leaves to curl and turn red. The leaves so affected fall off prematurely or remain functionless. Badly affected individuals die but the majority of them remain almost lifeless for sometime and then put on fresh leaves. They flower late and yield much less than the healthy ones. The disease so far as has been ascertained is not due to any insect or fungus. It is a physiological malformation brought about probably by the sudden change in atmosphere which causes excessive evaporation.

The severity of this blight varies according to season and locality. All American varieties newly introduced suffer badly and die very often without producing any seed. Remedy for this disease is not known. Breeding resistant types is possible and we have already made good progress in this direction.

III. IMPROVEMENT.

A. Mixed Condition of Dharwar American Cotton.

Two or more varieties of any one crop growing in the same tract sooner or later get mixed and it is not possible to maintain them pure unless extreme care is taken in selecting and preserving the seed. We have a number of Jowar varieties growing in Karnatak but every one of them is impure containing the mixture of others. In the same way the Dharwar American tract grows two kinds of cotton: (1) Dharwar American and (2) Kumpta and it is almost impossible in the whole of the tract to see them pure under cultivation notwithstanding the fact that the mixture has a disadvantage and the cultivators knowing it try to grow their crop as pure as possible. This is the condition of varieties which can be easily and clearly distinguished one from the other at all stages. The seeds are quite different and they can be picked out by any man without a mistake. So also the plants can be easily detected in the field from the earliest stage. With all these facilities for growing the two cottons pure the mixture persists, and in fields where great care is taken it often amounts to 6 per cent. or more.

Now we know that the seeds of Dharwar American originally came from America which was then growing a number of cottons of which New Orleans and Upland Georgian were the principal. The Court of Directors no doubt got the seed of one variety, *viz.*, New Orleans, for trial in India but that seed must have brought with it at least a small percentage of other American varieties growing at that time. Moreover in India itself the trial was not confined to one variety. A number of cottons similar to New Orleans were introduced and grown along with New Orleans. Of these the following are the chief:—

Serial number.	Nome.
1	Upland Georgian.
2	Sea Island.
3	Louisiana.
4	Mexican.
5	Barbados.
6	Pernambuco.
7	Bourbon.
8	Egyptian.

We do not know what care was taken on the Government Farm and in the District to keep these varieties pure ; but with all precautions then possible we can say without doubt that all these cottons mixed and crossed freely with each other and our Dharwar American cotton of to-day contains all these mixtures and crosses. Proofs are not wanting to support this assertion. If the crop in the tract is carefully examined we find that it is very much mixed no two plants in any field agreeing completely in all characters. We give below the variations in the more important characters observed in the crop of Dharwar American cotton grown at Gadag :—

(1) *Habit of branching*.—All plants are sympodial producing very few monopodia 1 to 3.

(2) *Hairiness of the stem and leaves*.—Plants are of three kinds with regard to this character :—(1) Very hairy, (2) Sparingly hairy and (3) non hairy. The first and second groups can be further divided according to the length of hairs which may be either short or long. This division is by all means important because we have found that hairy plants in general resist the red leaf blight better than the glabrous and of the hairy those with long hairs are more resistant than those with short hairs. Thus both the quantity and quality of hairs on stem and leaves appear to take an active part in resisting the disease. We have accordingly 5 different kinds as under :—

- (1) Hairs many and long.
- (2) Hairs many and short.
- (3) Hairs few and long.
- (4) Hairs few and short.
- (5) Hairs none.

(3) *Colour of the Petals*.—Two kinds of flowers are met with (1) Sulphur yellow and (2) white, the former being more common. Bright yellow flowers are rare but not altogether absent. The spot or eye in the flower is generally wanting but a few flowers possess either a faint or bright spot in them. The kind and percentage

of flowers in the Dharwar American crop are given below :—

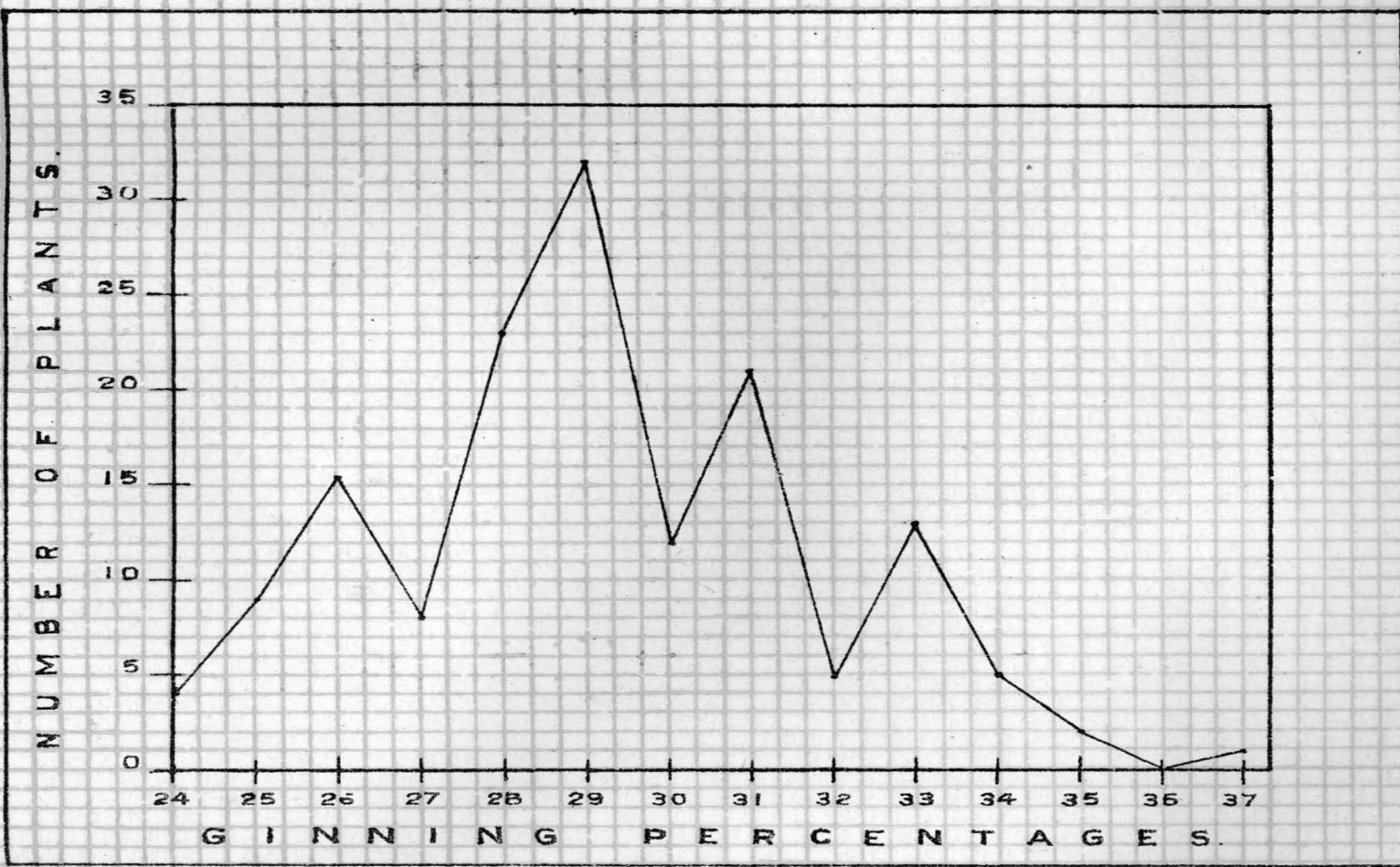
Serial Number.	Name.	Percentage.
1	Bright yellow with bright eye	0 02
2	Do. faint eye	0 00
3	Do. No eye	0 09
4	Sulphur yellow with bright eye	0 19
5	Do. faint eye	0 00
6	Do. No eye	79 41
7	White with bright eye	0 00
8	Do. faint eye	0 06
9	Do. no eye	20 23

(4) *Colour of the pollen grain.*—This is of 2 kinds, white and yellow.

(5) *Boll.*—The shape and size of bolls vary much on different individuals. A boll may be round or long or in some way intermediate between the two. In the same way it may be big, small or medium in size.

(6) *Ginning percentage.*—The ginning percentage or the proportion of lint to seed cotton also varies much. It varies in the case of different samples from 28 to 33 but the variation is still greater in the individual plants all from the same field. The following table and graph give the range and nature of variation of these :—

Ginning Percentage.	Frequency.	Remarks.
24	4	Mean 29.2.
25	9	
26	15	
27	8	
28	23	
29	32	
30	12	
31	21	
32	5	
33	13	
34	5	
35	2	
36	0	
37	1	



The percentage ranges from 24 to 37. The curve is multimodal having 4 distinct maxima at 26, 29, 31 and 33 due to a mingling of 2 or more different types.

(7) *Staple*.—This varies but little in commercial samples from $\frac{5}{8}$ th to $\frac{7}{8}$ th of an inch in length. On individual plants growing on the same plot however the variation is greater as seen from the table below :—

Staple length in inches.	Frequency.
0.3	8
0.4	16
0.5	7
0.6	24
0.7	45
0.8	33
0.9	11
1.0	6

(8) *Seed*.—Seeds are either fuzzy or naked the former predominating very much in all cases. The fuzzy seeds are again of 2 kinds green and white their proportion varying much in different samples. In some samples green seeds are more numerous, in others white. The green seeds can be further distinguished as bright green, oily green and faint green. We have thus the following 5 kinds :—

Number.	Name.	Proportion in one sample.
1	Bright green	18.7
2	Oily green	9.5
3	Faint green	27.9
4	White	42.9
5	Naked or black	1.00

From these observations we can conclude that Dharwar American crop as grown at present is very polymorphic in character. It contains a number of desirable and undesirable types affording thus great scope for improvement.

B. Ideal Type of Cotton for the Dharwar American Tract.

Climatic conditions play an important part in all such considerations. The ideal type need not necessarily exist under cultivation. It may or may not be even possible to

breed it. Still it is essential to have it in our mind because if we are right in our conception every step towards the ideal will be a move in the proper direction.

Rainfall in Karnatak is heavy, moderate or scanty and accordingly we have three divisions:(1) Mallad, (2) Transition, and (3) Desh. The average annual fall is roughly 40 inches for Mallad, 30 inches for Transition and 25 inches for Desh. This difference is rather insignificant. The distribution which is more important is however different. In Mallad most of the rain is Kharif falling in the months of June, July and August. The distribution is even in the transition area, all the six months from June to November having almost an equal quantity in each. In Desh the Kharif rains are of little consequence, the Rabi ones of September, October and November being heavy and important. The following table gives the quantity of rain and its distribution in one typical place of each region :—

Month.	Average rainfall in inches.		
	Mallad.	Transition.	Desh.
<i>Antimonsoon rain.</i>			
January to April	1.60	3.03	2.50
May	2.07	2.65	2.20
Total	3.67	5.68	4.70
<i>Kharif rain.</i>			
June	9.30	4.76	2.83
July	11.55	3.89	2.22
August	6.12	3.56	2.65
Total	26.97	12.21	7.70
<i>Rabi rain.</i>			
September	2.64	3.14	6.40
October	3.77	5.16	4.93
November	1.99	2.31	3.22
Total	8.40	10.94	14.55
Total for the year	39.04	28.83	26.95

Dharwar American tract lies partly in Desh and partly in the eastern part of transition region which is more like Desh in all particulars. Here the Kharif rains are not only scanty but often precarious. The September rains are more certain and sufficient to thoroughly wet the soil. For this reason cotton sowing is done in September at the earliest. It is also done in October especially when the September rains leave the land unworkable for a long period. A crop thus sown has hardly a duration of 2 to $2\frac{1}{2}$ months for completing its vegetative growth. It consequently makes what little progress is possible in that time and flowers in December. In the whole of the tract the height of the Dharwar American plants rarely exceeds 2 feet. The short duration of the vegetative period is not however entirely responsible for this. The moisture in the soil which is always insufficient has also a good deal to do with stunting. On the whole the conditions in the tract are unfavourable for producing rank growth which is so common in other cotton belts. This applies to the Kumpta cotton tract as well with some modification.

The type of plant best suited to these conditions therefore is one which is perfectly sympodial or nearly so. Monopodial types producing a large number of vegetative branches are entirely unsuited as they have always left the ground without flowering whenever they are tried. Dharwar American cotton is almost sympodial producing very few, 1 to 3 monopodia. But even this small number of monopodia constitutes a disadvantage as they often grow at the cost of the main shoot and the root has to nourish four stems all equally high instead of one. All the four are not however equally productive. The central or the main one is the earliest to flower and often carries more number of bolls than all the monopodia put together. This shows clearly that all vegetative shoots except the main one are more or less superfluous.

Cotton plants do not generally grow tall in the Dharwar American tract as already stated. If such plants have long internodes the numbers of fruit bearing branches will be very small and the yield consequently poor. A plant with short internode may therefore be of advantage by its capacity to bear larger number of fruiting branches. But it has been observed that short internodes often injuriously affect the development of the fruiting branches so that granting

that the number of such branches does increase, the total number of bolls produced actually suffers. Again we have found by growing types with short and long internodes under identical conditions that the difference between the two lies in their height and not in the number of nodes which is the same for both. If this is true for all cases, which we are not sure for the present, then a plant with short internode will not be an advantage as is generally supposed but it may be on the contrary a disadvantage by producing the same number of fruiting branches of less vigour. Under these circumstances we have taken a tall plant with internodes sufficiently long to promote healthy development of the fruiting branches but not more to be the ideal for our tract.

Rains practically cease in the month of October and the cotton plant starts flowering by the end of November. It continues flowering during December, January and even February. The percentage of flowers formed during these months is roughly, 5 for November, 35 for December, 45 for January and 15 for February. All these flowers, however, do not form into bolls. Large number of them shed for reasons which we do not fully know. It has been found that in one particular year which was fairly an average one only 41 per cent. of the flowers set bolls the remaining 59 per cent. having shed. Insufficient rain and dry easterly winds increase the amount of shedding. Heavy showers falling at the time of flowering have also the same effect. In the same way other things being equal bushy types shed more than the erect. 600 lbs. of Kapas per acre is considered to be a very good yield in the Dharwar American tract and small plant with practically no side branching often give this yield while the bushy ones growing 6 feet tall with numerous side branches fail. This is mainly due to the difference in shedding. We thus find that one of the methods probably the best of increasing the per acre yield is to reduce the amount of shedding on the kind of plant which we have described.

We have seen that in all cottons growing in the tract late flowers have a less chance of success than the early. It was observed in the case of 1 pure strain that the percentage of bolls formed to the total number of flowers opened during the different months was 50 for December, 30 for January and 10 for February. This shows that

late flowers and late flowering varieties are at a disadvantage in this respect. We therefore want our type to be early and produce all or most of its flowers in December. This also has another important advantage. We shall be in that case able to pick our cotton completely in one or at the most two pickings. This not only saves the cost and trouble of two or more pickings but also minimises the danger of the antimonsoon showers washing away the cotton from the plants which is so common in the whole of the tract.

Next thing we have to consider is the size of the boll. Other things being the same the bigger the boll the larger is the yield. But we often see that the big balled types are shy bearers. We have not however studied the correlation between the size and number of bolls. Instances in which big boll, and large number have combined are not altogether wanting. We therefore think it possible to have on our type big bolls without in any way interfering with its prolificness.

In short, the type which is perfectly sympodial, growing tall with internodes sufficiently long to promote the healthy development of the fruiting branches, flowering early so as to produce all its flowers in the month of December and bearing big bolls, is the one which is ideal for the Dharwar American tract.

C. Recent Attempts to improve the Cotton of the Tract.

Bombay Agricultural Department opened an experimental farm at Dharwar in the year 1904 when the problem of improving the cottons of Bombay Karnatak was again taken up. Consequently a number of American, Egyptian and Sea Island cotton varieties were obtained from many countries and given a trial at Dharwar.* This continued for three years during which it was found that the conditions of Dharwar were unsuited for all American cottons including Dharwar American as they suffered seriously from the attack of red leaf blight. In 1908 therefore another farm was started specially for American cottons at Gadag, the centre of Dharwar American cultivation, to which the Dharwar experiments were then transferred. Here these and other fresh varieties were tried. But all with the one exception of Madras Cambodia entirely failed. The latter gave

* Bulletin No. 70 of 1915, Bombay Agricultural Department may be referred for details.

slightly better yield and far better ginning outturn than Dharwar American cotton and was first distributed in Gadag and Ron Talukas and then in other Talukas of Dharwar and Bijapur Districts. Since then it has kept its superiority in these two respects but the staple which is short and weak is seriously engaging our attention. For the present it has been decided to temporarily stop its distribution as the seed is much mixed.

A number of crosses were also made and tried at Dharwar and Gadag. Of these we have only one, a cross between Culpepper and Christopher which is somewhat promising. Its yield and ginning outturn are as good as those of Dharwar American but the staple is considerably better. It has a good scope provided the ginning percentage is increased.

The mixed nature of Dharwar American cotton seed was noticed for the first time in the year 1909 when green and white seeds were separated and sown to test their value. This experiment was continued for three years in two of which the crop sown with green seeds gave better results. In 1911 white and yellow flowered plants were in the same way separately picked from the general crop and their seed sown in the following year. The crop of white flowered plants gave better yield than that of yellow flowered. These results, however, were of doubtful value because the crop was in no case pure it being grown from seed collectively taken.

Individual selection was started in the year 1910 for length of staple in the crop of Dharwar American grown with green seeds. The selections were continued for two years during which a good deal of splitting was noticed in all of them and they had to be discontinued for that reason. In 1913 which was a favourable year for red leaf blight, a tour was made in Ranibennur Taluka to inspect the crop of Dharwar American grown there, when it was clearly noticed that the cotton was entirely Upland in character and almost free from red leaf blight. In the same year, therefore, a number of Upland plants were individually selected at Gadag taking all good characters into consideration, *viz.*, resistance to red leaf blight, prolificness, ginning outturn and staple. In the following year the progeny of only 3 plants were found to be uniform, possessing all the characters for which they were selected. Other plants were at once rejected and further attention given to these alone. From these the best

one was isolated on the consideration of the ideal type already described.

The type thus selected possesses many desirable characters. It grows tall with one or at the most two monopodia, bears strong fruiting branches, flowers early and produces big bolls containing Kapas of higher ginning percentage and long staple. Its stem and leaves are thickly studded with long hairs by virtue of which it successfully resists the red leaf blight. The colour of the flower is white and that of the seed is green, and if these two are really correlated with the high yield as indicated by previous experiments they too are valuable acquisitions. The following statement gives the per acre yield and ginning percentage of this strain, designated as Gadag I, and also of ordinary Darwar American cotton in the comparative trials done on the Gadag farm :—

Year.	Gadag I.			Darwar American.		
	Yield per acre of Kapas.	Ginning percentage.	Yield of lint per acre.	Yield per acre Kapas.	Ginning percentage.	Yield of lint per acre.
1915	264	34.5	91	230	29.0	67
1916	605	33.0	200	530	29.0	154
1917	640	35.3	226	588	30.6	176
1918	484	35.0	169	372	31.0	155
1919	188	33.0	62	98	28.2	28 Bad year.
Average	436	34.2	149	361	29.6	118

Gadag I, has thus given on an average 26 per cent. of clean cotton more per acre than Darwar American. Its superiority in staple is also marked the latter being about $\frac{1}{8}$ th of an inch longer and uniform. The cotton of Gadag I, is being valued about Rs. 20 more per candy than Dharwar American, by Messrs. Tata and Sons, Bombay. It has thus reached a stage of going out in the tract to replace the inferior mixture.

But even before this the cotton has gained some popularity round about Gadag through the efforts of some zealous landlords among whom the names of Messrs. E. V. Nadger of Kurtakoti and N. R. Huilgol of Gadag deserve special mention. Mr. E. V. Nadger took a small quantity of seed in the year 1915 and multiplied it very carefully on his own lands. He had little difficulty in doing so because he is also the owner of a gin in his village. The seed thus multiplied is now sown on the whole of his cotton area which is annually about 600 acres. He is also distributing the seed to other cultivators in the village. Mr. N. R. Huilgol as a member of the Gadag Betigeri Seed Society first undertook to grow Gadag I, for trial in his fields in the year 1916. Since then he is not only an admirer of that cotton but also an active and careful seed grower of the Agricultural Department. The better yielding capacity of Gadag I, combined with its power to resist red leaf blight, a very high ginning outturn and good staple has created a great demand for seed and we hope to distribute a very large quantity of it in the tract, during the coming season. The local merchants too are not slow in appreciating its merits. They are quite willing to give a good price as evidenced from the details of the auction sales given below :—

Details of Auction Sale at Gadag during 1919-1920.

Kind of Kapas.	Ginning percentage.	Price per Naga of 1,344 lbs.
		Rs.
Gadag I, 1st Class	34.00	320
- Do. 2nd "	33.00	290
Darwar American Ordinary	27.00	230

We have thus succeeded in obtaining a type which suits the tract better and which is superior in almost all good characters to the Ordinary Dharwar American Mixture. This constitutes a great improvement as the growers and merchants are already realising considerable amount of profit from it. But it is only a small beginning. The present pure strain is capable of further improvement in all directions especially in staple and we have by no means lost sight of this rich prospect which is now before us.

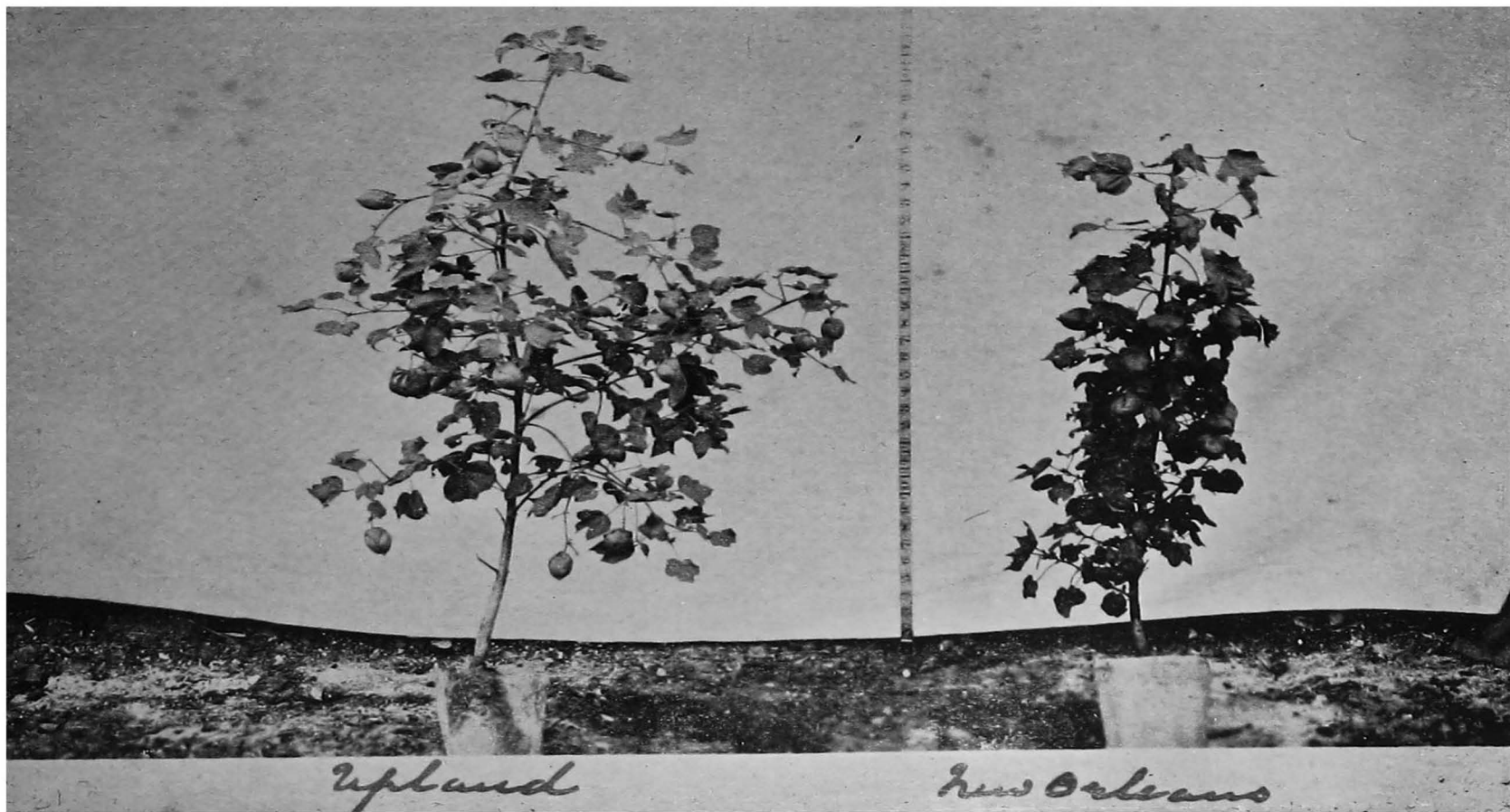
List of Plates.

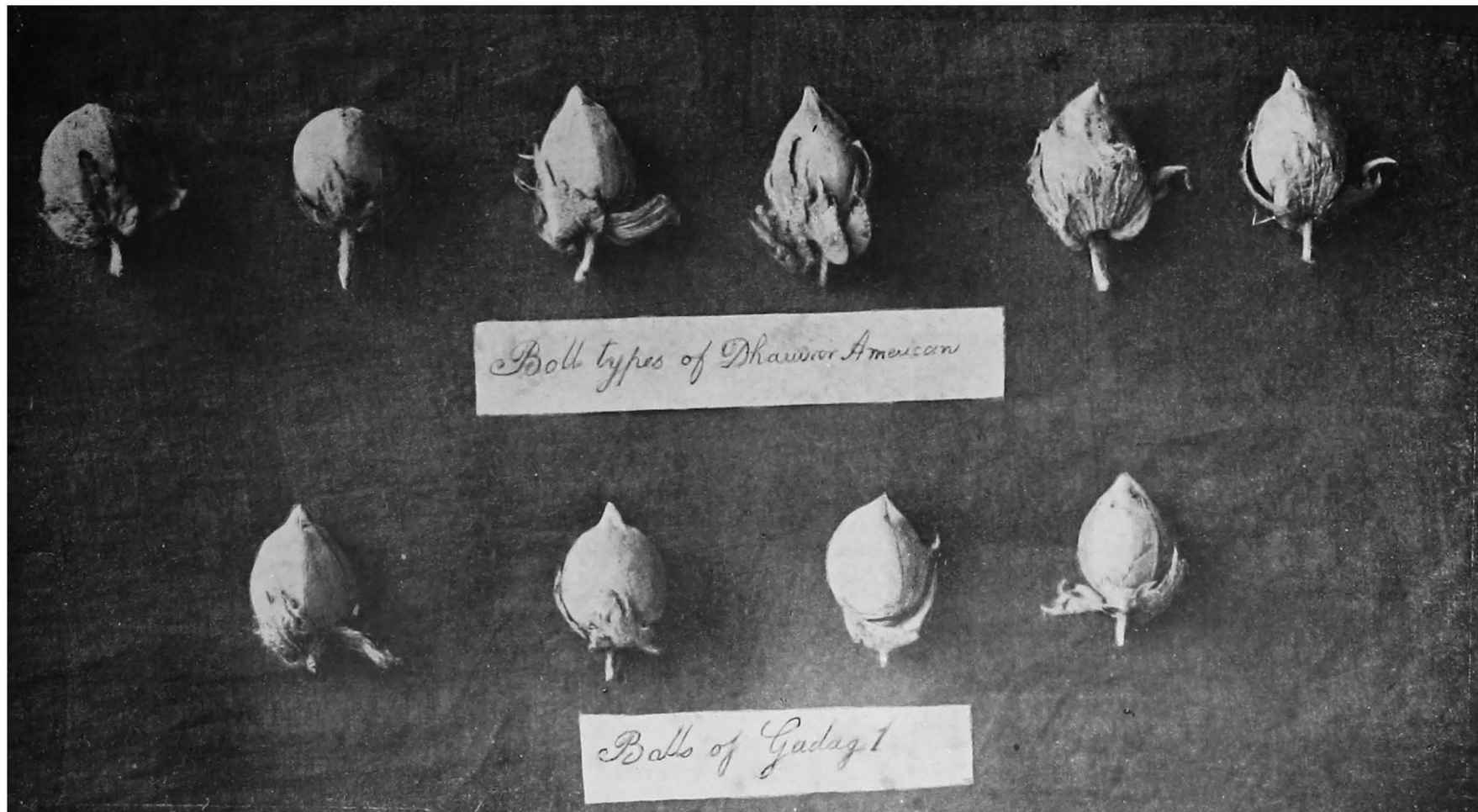
1. Upland and New Orleans cotton plants.
2. Boll types in Dharwar American Cotton.

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2. Kulkarni and Kottur Improvement of Cotton in Bombay Presidency, Bulletin No. 70 of 1915.
3. Bombay Gazetteer, Dharwar District.
4. Annual Reports of Dharwar and Gadag Experimental Farms.
5. Statistical Atlas.

PLATE No. 1.





THE GANESHKHIND BOTANICAL GARDEN, KIRKEE.

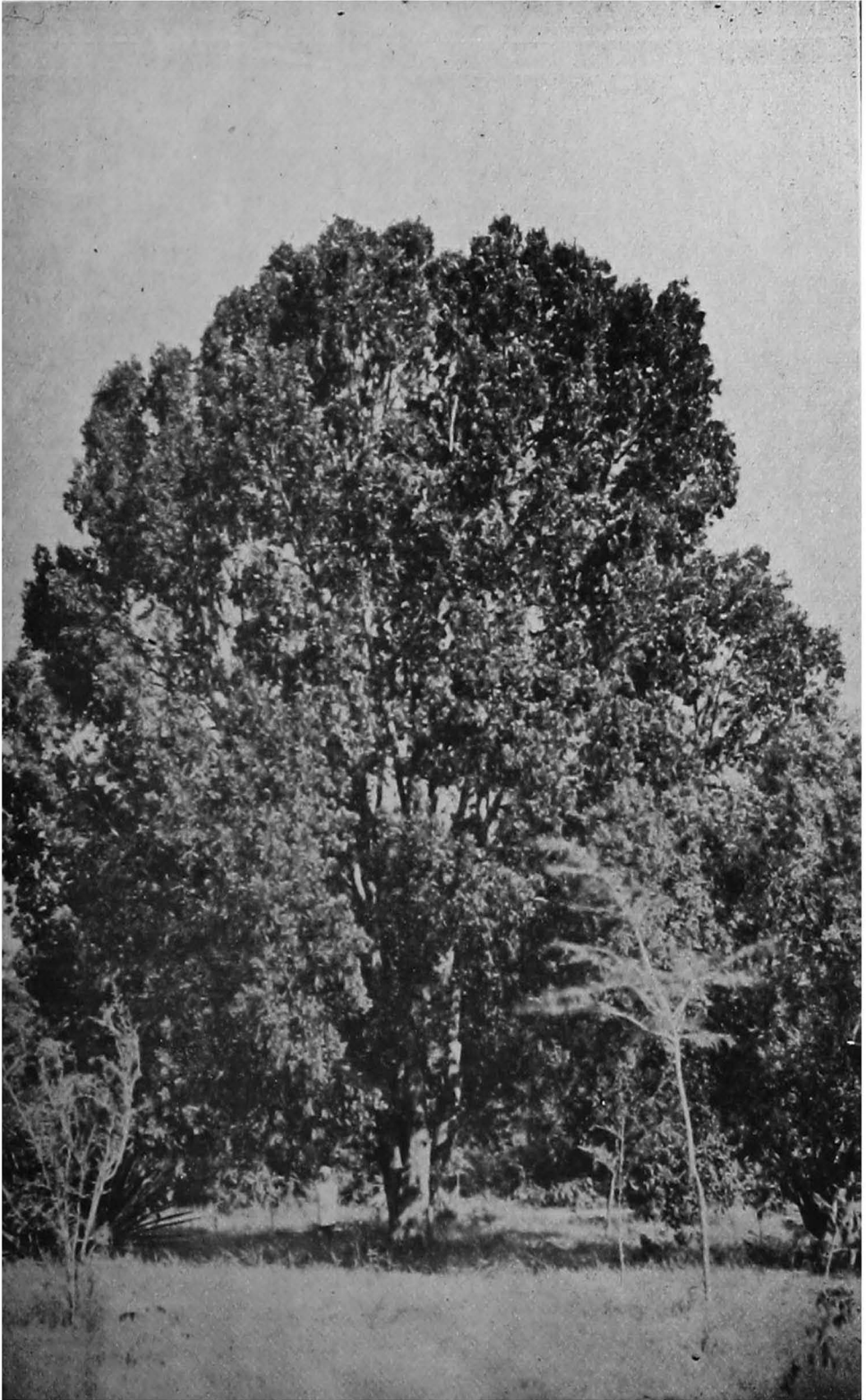
The Ganeshkhind Botanical Garden is of 46 years' duration as regards experimental work alone. No other farm or garden of the Bombay Agricultural Department, seems to have conducted experiments from so remote a date. However, it existed even prior to the above mentioned period, as far back as the Peshwas, though the exact time cannot accurately be traced. Its antiquity can, to a certain extent, be learned from the old mango trees said to have been planted at that time (Photo 1).

Experimental work appears to have been started about the year 1873. A brief account of the experiments conducted and the results obtained may be of some interest.

* The Botanical Garden at Ganeshkhind was started in 1873, and along with the Hivra Garden has since been under the superintendence of Mr. G. M. Woodrow. The principal object of these gardens is to supply the Medical Department with drugs. In 1872-73, the outturn of the garden included 700 lbs. of Senna, 1,300 lbs. of Henbane, and 1,036 lbs. of Dandelion. During the same year the chief produce of the laboratory was 107 lbs. of extract of colocynth compound, 56 lbs. of extract of hyoscyamus, 1,621 lbs. of groundnut oil, 7,190 lbs. of castor-oil and 11 lbs. of croton-oil. In that year experiments were made with various artificial manures, nitro-phosphates, citrate, dissolved bones, nitrate of soda, hop manure, and super-phosphate. The income of the gardens amounted to £164 (Rs. 1,640) and the

* Extract from "the Bombay Gazetteer; Deccan (Poona)," Vol. XVIII, part II, 1885.
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expenditure £319 (Rs. 3,190). In 1873-74, experiments were made with European manures (artificial); the result was not satisfactory. It was proved that silt from the drains of Poona city is a valuable manure at least equal for one year's crop to dung from oil-cake fed to cattle. Many new ornamental plants were introduced, the most valuable of which was the *Exogonium purga*, the plant which yields the drug jalap. Experiments were also made for the growth of fibre for paper. The income was £352 (Rs. 3,520) and the expenditure £1,222 (Rs. 12,220) besides £558 (Rs. 5,580) spent on the laboratory building from a fund set apart for the purpose. In 1874-75, the income was £482 (Rs. 4,820) and the expenditure £1,257 (Rs. 12,570). The area under tillage was 57 acres, 7 of which were watered. One fact was ascertained that prickly-pear made a valuable manure if it was left to rot in a cistern through which water of an irrigation channel was led. Some new descriptions of trees were added. A fairly successful attempt was made to grow vanilla. Flax was also grown of fair quantity but of excessive dearness. Unsuccessful attempts were made to get paper from san stalks and plantain fibre. Most of the cork acorns brought from England arrived dead. In 1875-76, the income of the garden amounted to £660 (Rs. 6,600) and the expenditure to £1,268 (Rs. 12,680). The most important new introductions were *Balsamocarpon brevifolium*, a plant yielding pods useful in tanning, and the Liberian coffee. Cereal crops were raised with a view to selecting the seeds. 3,000 half-standard roses were ready for distribution. A list of the medical plants was printed and indents became more frequent. In 1876-77, the income of the garden amounted to £951 (Rs. 9,510) and the expenditure to £1,285 (Rs. 12,850). Experiments with *Wagatea spicata*, a climbing shrub and a native of the Konkan, showed that its seeds contained a high proportion, viz., 15 per cent of tannic acid. A satisfactory feature in the working of the garden was the



2. A 45-YEAR-OLD MAHOGANY TREE.

(Swietenia Mahagoni).

of scientific utility. Botanical teaching was begun at the end of February 1879, by means of lectures at the gardens of the College of Science, and at the Deccan College, Poona, with illustrations of specimens collected by the Superintendent. The average attendance was 51 students.

Experiments with Nankin cotton showed that it could not be grown profitably in the Deccan. The sample to the Chamber of Commerce was estimated to be worth £5 (Rs. 50) less than the common samples of Dholera. The forage plant, *Reana luxuriens*, was found to be no better than sugarcane when grown in rich soil and irrigated, and worse than Jowar when treated as dry crop. The income of the garden was £740 (Rs. 7,400) besides £134 (Rs. 1,340) the value of the oil on hand, and the expenditure £1,282 (Rs. 12,820), i.e., a net cost of £408 (Rs. 4,080). In 1879-80, the room formerly occupied by the oil pressing machinery was partially fitted as an herbarium and specimens of about 1,700 species were arranged according to their Natural Orders. Some of these were identified and the rest were sent to the Royal Herbarium at Kew for comparison. Considerable additions were made to the library which was used by a large number of botanical and agricultural students. Botanical teaching was continued during the year at the gardens and at the adjacent Poona colleges. The average attendance at the gardens fell from 59 to 19, as the students were allowed to pass the examinations without attending at the gardens. Six trained native gardeners or malis were sent out during the year and a demand for trained men continued much greater than the supply.

Experiments with the thornless *Opuntia* or prickly-pear, which can be easily skinned and is then a favourite food for cattle, showed that it grows freely as a fence and is not likely to prove troublesome as it does not grow from seed. The yield of the forage grass* *Euchlaena luxurians* seemed

* *Reana*.

nearly the same as that of guineagrass. A crop sown in November and cut in April, gave 16 tons of green forage per acre per cutting. Fifty mango trees of the finest varieties were planted for stocks from which grafts could be taken for distribution. The demand for imported seeds had risen from £69 (Rs. 690) in 1875 to £124 (Rs. 1,240). Experiments with lucern grass seemed to prove the French variety superior to the acclimatised variety. The plant was quite as vigorous, the stock was more delicate, and the seed was only half the weight. The receipts of the garden amounted to £946 (Rs. 9,460) and the charges to £1,554 (Rs. 15,540). In 1880-81, additions to the herbarium brought up the collection to about 2,080 species, of which about 1,080 were identified. Botanical teaching was continued at the gardens. A number of full grown specimens of *Albizzia procera*, one of the local trees which in cold season of 1878-79 had been transplanted without soil on the roots, showed satisfactory results. *Euchlaena luxurians* was again grown for forage. It proved a vigorous grass when highly manured and watered, but not superior to sugarcane. Twenty mango trees of the finest varieties were planted out for stock, raising to 100-102 the number of trees whose grafts were suitable for distribution. The demand for imported seeds was about the same as in the previous year. The garden receipts amounted to £340 (Rs. 3,400) and the charges to £768 (Rs. 7,680). In 1881-82, the general condition of the garden was improving and the number of visitors was increasing. The receipts, derived from the sale of fruit trees, vegetable seeds, taraxicum, and some timber, amounted to £637 (Rs. 6,370) and charges to £1,046 (Rs. 10,460). A mango-steen plant from Singapore died from cold in November. The local Kokam or wild mangosteen plants were in good condition. Potatoes received from the Secretary of State grew surprisingly well. In May 1882, the carob tree yielded a crop of 30 lbs. weight of pods, the greater part of which were equal in size to the imported pods. An attempt

to propagate this tree by layering failed, but by grafting was very successful. 447 mangoes were grafted with choice sorts at a cost of $10\frac{1}{2}d.$ (7as. and 2 pies) each. The herbarium building was altered and repaired and numerous specimens were added. The Superintendent Mr. Woodrow, lectured on vegetable physiology and Systematic Botany and gave 11 garden demonstrations in Systematic and Economic Botany. The average attendance was 12 students. Experiments were made in collecting the India-rubber-yielding milk sap of the *Cryptostegia Grandiflora*, a beautiful climber. The average yield was found to be 20 grains and acre yield 12 lbs. As the plant would not bear tapping more than twice a year, the yearly acre outturn would be 24 lbs. of caoutchouc. The cost of collection was 2 sh. (Re. 1) per pound, which might perhaps be reduced to 1sh. (8 as.). The value of the India rubber may be estimated at 2sh. (Re. 1) a pound. The result was therefore not encouraging. In 1883, 2,001 mango trees were grafted with choice grafts at a cost of 10d. (6 as. 8 p.) each, and in 1884, 4,000 more were prepared at a cost of 9d. (6 as.) each."

The above extract describes the work the garden did during ten years. The experiments conducted were varied and were of an economic nature. From this period, till the inception of the Agricultural Department, it underwent many changes, and there is very little on record regarding the experiments done.

Since 1902, when the Agricultural Department was fully organized, the original purpose of the garden as a source of drug supply was abandoned and it became gradually a place for experiments in Economic Botany. Experiments on various rubbers, fibres, food and grain crops were accordingly taken in hand. Special investigations in the botany of the cotton were carried out from 1904

till 1908. Wheat was also studied as regards rust resistance.

The following rubber plants were selected for trial :—

Ceara (*Manihot Glaziovii*).
 Para (*Hevea braziliensis*).
Landolphia Owariensis.
Kicksia africana.
Ficus elastica.
Cryptostegia grandiflora.
Raphionacme utilis.

Ceara.—This was a failure in the Botanical Garden. It is exceedingly intolerant of long continued moisture in black soils. During spells of cold nights, the leading shoots often died. On recovery the plant threw out forked branches thus marring their symmetry. The trees cracked badly from Sun scorch and the exposed surfaces became diseased. The plants also suffered considerably from tapping which was done by the usual tapping knife. The latex coagulated too quickly for collection to be efficient. The yield of rubber was unsatisfactory. On the whole, it may fairly be said that it does not suit this part of the Presidency.

Para rubber.—Though our experience of this is not so great as in the case of Ceara, we can say that it is not suited to Deccan tracts, on account of its extreme sensitiveness to a long-continued dry season.

Castilloa elastica.—After trials extending for about seven years, this plant proved to be absolutely unsatisfactory for the Deccan and in company with Para, it is merely grown under shelter as a natural curiosity.

Cryptostegia grandiflora.—A sample of this rubber was sent to the Imperial Institute in 1906 and the following is the brief report of the examination.

“The chief defect of the rubber is the presence of the large amount of insoluble matter consisting

of vegetable and mineral impurities. The presence of the mineral impurities points to the contamination of the rubber, possibly the scrap rubber present in the sample by contact with the soil and precaution should be taken to avoid this in future. The percentage of caoutchouc is rather low, but this is chiefly due to the excessive amount of the impurities contained in the sample."

Funtumia elastica.—Known under the synonym of *Kicksia africana*, was remarkably slow in its growth (though slow growth is said to be characteristic of this plant) and was not worth growing.

Ficus elastica.—This tree has been found to grow well here and can easily be propagated by means of layers. It was found that layers made in the rains rooted more freely than layers made in the dry months. A sample of rubber obtained from this plant was sent to the Reporter on Economic Products to the Government of India, in the year 1906 and it was gratifying to find that this Assam rubber plant, produced rubber more valuable than that collected in its native country, as will be seen from the following report.

"Your rubber contains much less resin than the trees of the Government plantation of Assam."

The work done on *Landolphia* and *Raphionaeme* gave no conclusive results.

Fibres.

Among the fibre plants tried were the following :—

- Corchorus capsularis (Jute)
- Boehmeria nivea (Ramie fibre)
- * Agave sisalana (Sisal hemp)
- Furcraea gigantea (Mauritious hemp)
- Musa sapientum (Plantain)
- Malachra capitata

* Other species of Agave were tried, viz. Agave Wightii, Agave Cantala and Agave Vera-Cruz.

Regarding jute, a detailed description of its cultivation appears in the Garden's annual report for the year 1906-07, pp. 7 to 10. The following are a few of the important facts obtained from three years' experience in Ganeshkhind Botanical Garden, Bassein, Manjri and Dharwar farms.

Except in Ganeshkhind Botanical Garden, the jute fibre produced, was of poor quality lacking in one or other characteristic of good jute, the chief defect being in length.

In the Bombay Presidency, jute requires very rich soil and plenty of water.

It must be planted not later than April. Given these conditions and Poona climate, jute equal in quality to fair to good Bengal jute can be produced though a less crop per acre is obtained.

The expenses of cultivation have in most cases exceeded the income, even in the case where it was taken in rotation with gram. It remains to be seen whether jute can be grown along with other crops just as Sann (*Crotalaria juncea*) and Ambadi (*Hibiscus cannabinus*) are generally grown. There does not seem to be much difficulty in selling the fibre. The experience of the Garden was that 'Mangs' appreciated the value of the fibre and were willing to pay as much as one rupee per 6 seers, i. e., Rs. 6-10-8 per maund of 80 lbs. for samples valued at Rs. 5-4-0 to Rs. 5-8-0 by Mr. Finlow, the jute expert of Assam.

Ramie fibre.—Several years' trials of this indicated that the soil of the Deccan is unsuited to this plant. It requires more evenly distributed rainfall and lighter soil than we have. It has also been found that the soil is probably most in fault as the plants grown in pots in prepared compost thrive fairly well.

Sisal hemp.—All the experiments went to prove that this fibre plant requires as good cultivation as any other crop if it is to yield a profit. Plants grown under shade were much larger than those grown in the open.

A comparative test made in 1908-09, of the amount and quantity of fibre obtainable from shaded and unshaded plants showed little difference in the percentage of fibre in the two types of plants.

Malachra capitata.—This plant which grows so well in Bombay during the rains, was after two years' trials found unsuitable for cultivation in the Deccan, owing to its low and branching habit induced by the lighter rainfall.

Agave species.—The following pronouncement of Mr Finlow made in 1908, regarding the culture of Agaves generally may be of interest to intending growers.

“ I have very little faith at present in the prospects for the successful cultivation of Agave, other than Sisal hemp. Even the latter has failed to fulfil all expectations and some of the Sisal plantations put out in Eastern Bengal a few years ago, are now being taken out. It is to be inferred from this that even Sisal is not certain to succeed and that caution should therefore be exercised in planting it.”

“ As *Agave rigida* (of which Sisal hemp is a variety) is the best of the agave fibres at present in the market and the one which commands the highest price, it will be seen that the chances of success, as far as export trade is concerned, with any variety of agave other than Sisal, are not great. The yield is often less and the price low, while the working expenses are much the same as with Sisal.”

Cotton.—Investigations in the botany of cotton were taken up from 1903 and continued till 1909. In 1906-07, 282 varieties were tried. The seeds had been obtained from Mr. F. J. Tyler of the Bureau of Plant Industry, U. S. A. In 1907, 321 varieties were tried.

Besides these, special varieties were experimented with for nearly six years and the following is the summary of the trials made.

Kidney cotton.—On account of the difficulty in satisfying its requirements of perfect shelter in a tree-less country like the Deccan, this variety was not found promising.

Bourbon cotton.—During the first year the plants did not boll. The average yield of four years was 933 lbs. (seed cotton) per acre. The cotton greatly improved both in colour and staple.

Dharwar-American.—This was found to give a low yield and therefore to be unsatisfactory as a dry crop in the Deccan.

Other varieties such as Dharwar-American, Ghogari, Soft Peruvian, Peruvian and Spence cottons were tried and of these, Soft Peruvian was found to maintain its superiority over the others.

Yam.—Several varieties of Yams were under cultivation for four years from the year 1904. It was found that none of the varieties were particularly worth recommending for an extended trial, the average outturn per acre being too low in comparison with that produced in their native climate. Besides, there was no good market for them.

Tapioca.—Experiments on tapioca were carried on for two years with a view to determine (1) yield of tubers with and without irrigation. (2) Whether there are true varieties. (3) Whether they differ in the amount of Prussic acid. (4) Whether the age of the cutting affects the figure and appearance of the plant. (5) Whether the leaves of the plant change their characters during the life of the plant. (6) The age of the plant when Prussic acid appears in the tubers. (7) The effect of shade on tapioca. The following results were obtained :—

(1) The yield of raw tubers in the year 1908-09 from the irrigated plot was at the rate of 3,343 lbs. per acre (as calculated from a 14 guntha plot) and that of the non-irrigated was 380 lbs. per acre. Neither of these areas had, however, received manure.

(2 to 5) These experiments were not continued for a sufficiently long time and nothing definite can be reported.

(6) Six plants of unknown varieties were tested for the prussic acid content of the tubers at different times ; but no prussic acid was found at any time.

(7) Tapioca plants under shade and without irrigation grew tall and weak and showed a tendency to droop.

Since 1908, regular and systematic work on the different fruit trees was undertaken. The following is a summary of the work done and the results obtained.

Mango.

The following is the summary of the experimental work done since 1910 :—

I.—*The comparison of the different methods of mango propagation.*—Various methods of propagating the mango were tried, viz., by :—

- | | |
|---------------|----------------|
| (a) Cuttings. | (b) Layers. |
| (c) Gooty. | (d) Graftings. |
| (e) Buddings. | (f) Seeds. |

(a) The mango failed to respond to this method.

(b & c) The mango is amenable to this treatment but the methods cannot replace grafting as the percentage of success is not very great and as the roots are slow in forming. The after-growth and fruiting of these are still undetermined.

(d) The different methods of grafting, viz., Tongue, Enarch, Whip, Saddle, Crown and Side were tried with the result that Simple Approach or Enarch grafting was found to be superior to all the other methods, the percentage of success obtained in others except Tongue graft

being exceedingly small. The Crown graft when it succeeds is an admirable method of renewing old trees and the side-graft has also been found to be quite as good. Of the two methods the side-graft is the better as the top of the tree is not sacrificed. Crown grafted trees make vigorous growths and fruit in about 5 years though flowering may be induced earlier.

(e) This method has so far been found to be unsatisfactory for want of a greater percentage of success. At present we cannot recommend this method until a greater percentage of success is assured.

(f) This has been supposed to be an uncertain means of propagation as desirable varieties cannot be maintained true to parental types. But no statistical statements are forthcoming. To test the truth or otherwise of this supposition, seeds of known varieties have been planted. These are now 4 to 5 year old plants.

Besides, the Indian Mangoes have been said to be monoembryonic as they produce only one seedling. Some of the foreign mangoes especially those of Philippines are said to be polyembryonic producing more than one seedling, all of which except one that is of a heterozygotic character form plants true to the original types. Such varieties as Carabao and Pico which are said to be polyembryonic have been introduced at the Ganeshkhind Botanical Garden, and have produced two-year-old seedlings. The study of this is continued and the results are awaited with interest.

II.—*The best method of raising stock plants for the purpose of grafting.*—The method of putting seeds directly in pots and growing them there taking care to transfer them to bigger pots from time to time, has been found to be better than the method of raising them in the ground and then transplanting them into pots, as by such transplantation the mango seedlings suffer badly.

III.—*Grafting the mango on stocks other than the mango.*

—Trials of grafting were done on the following plants of the same natural order.

- | | |
|----------------------------------|-------------------------------|
| 1. <i>Semecarpus anacardium.</i> | 2. <i>Holigama Grahamii.</i> |
| 3. <i>Spondias mangifera.</i> | 4. <i>Spondias acuminata.</i> |

All trials met with failure.

IV.—*Study of the position of the inflorescence on different vegetative growths with a view to facilitate pruning.*—The following are a few of the salient facts :—

1. There is no fixity in the place of appearance of the inflorescence. It is found on growths of all seasons, viz. rainy-season, cold weather and hot weather, there being generally three growths per annum.

2. A large number of inflorescences appeared on hot weather or on rainy-season growths of different ages.

3. The same branch sometimes produced inflorescences for two successive years, without the intervention of vegetative growth.

4. Sometimes vegetative growths during January and February appeared and inflorescences were also found on these.

5. In the majority of cases, the inflorescence was terminal but axillary ones were not uncommon.

Since the inflorescences fluctuate so much with regard to their positions on particular growths, there is no guide for the adoption of pruning methods. Hence, pruning the Mango for flower production cannot be recommended.

V.—*The bearing of the mango out of season.*—Trials made were :—

(a) By taking grafts of those trees that were reputed to bear out of season and planting them,

(b) By exposing the roots of plants and giving them a resting period as is done in the case of citrus and figs.

(c) By the adoption of different pruning methods.

Results obtained :—(a) The plants have not as yet come to bearing and hence nothing definite can at present be said.

(b) The mango, unlike figs and citrus, is an evergreen tree and did not lend itself to this treatment.

(c) The various prunings resulted in the production of a large number of vegetative growths and, where inflorescences were produced, they were found to be small and weakly.

VI.—*The cross-pollination of the mango*.—Experiments regarding this were carried on from 1911 to 1914 but only three fruits were obtained in 1914, the attempts at getting fruits in other years having failed. This is not to be wondered at, considering the few flowers that set in the ordinary way of fertilisation and the lavish pruning of these that naturally takes place.

VII.—The study of the Morphology, Anatomy and Physiology of the mango inflorescence, normal and abnormal, has been done and has formed part of separate papers.

VIII.—The study of all insects of the mango has been done with a view to find out their life-histories and the methods of controlling them. Insecticides against Jassids and fruit flies have not met with very encouraging results.

IX.—Experiments in the packing of mango fruits and grafted plants for despatch to places in India and outside were done. Grafted plants were successfully sent to Egypt and to the United States of America. The desiderata for good packing are as follows :—

1. The plants should be small and hardy with dormant terminal buds.

2. They should be free from diseased or weakly branches.

3. Watering should be arranged for en route.

The packing of mango fruits to foreign countries did not meet with success and it appears that until cold storage is provided for mangoes on the Europe-bound steamers, the fruits will not arrive in good condition.

X.—*The canning of the mango.*—Experiments on this were tried for two years with an American apparatus and the canned juice of some varieties kept well. More trials are, however, needed before the experiment can be concluded.

Besides the above, several minor experiments regarding salt-manuring, the manuring of mango seedlings, the renovation of neglected plantations, the comparison of dug and undug plots, the packing of mango scions, the transplantation of mango seedlings, the ripeness of mango fruits etc., were conducted, the details of which will be found in Bulletin 103 of 1920, "The Book of Mango," Bombay Department of Agriculture.

Pomegranates.

Seven varieties of this crop were under trial from the year 1905. Three of these were local, two from Sangamner and two foreign (Kabul and Muscat). All were grown from seeds of specially-selected fruits. The foreign varieties made poor and stunted growths and failed to bear fruit even after eight years' growth. Grafts of Kabul variety on local stocks also failed to fruit even after seven years' growth. The following trials were conducted for nearly four years :—

1. The comparison of different methods of irrigation, viz., Basin, Trench and Ring systems.

2. Remedial measures against the insect borer (*Virachola isocrates*) locally called 'Sursa'.

3. Comparison of grassed and cultivated lines of fruit trees.

Results.—The trench system of irrigation proved to be unsatisfactory as the trees began to show signs of drought, reacting on the yield, which was consequently very low. The ring method showed the advantages of economy in the amount of water given and the avoidance of any rot of the stem at the collar.

2. Attempts were made to prevent insect attack, by bagging the fruits immediately after fertilisation. Paper bags proved most unsatisfactory as they tore badly. Even paper bags soaked in paraffin wax were not found to be of much use as water entered the bags along the fruit stalk and caused rotting of the fruits. Cloth bags were effective and the cost came to 4 pies each. If carefully used, each bag served for two years. Comparison was made with crude oil emulsion versus tobacco water. This resulted in favour of the crude oil emulsion.

3. In this experiment the weeds as they grew were cut and kept as a mulch 3 to 4 times during the year. The difference between the two plots was not appreciable.

Bananas.

Experiments were started on the following lines:—

1. To observe the morphology of the inflorescences and flowers in *Musa sapientum* and *Musa superba* (wild plantain).

2. To study the phenomena of pollination and fertilisation in these species.

3. To study the seed production of *Musa superba* and the non-production of seed in *Musa sapientum*.

Results.—1. The ovary of *Musa superba* did not swell without pollination but that of *Musa sapientum* did.

2. The stigma of *Musa sapientum* flower did not respond to the pollen of either *Musa sapientum* or *Musa superba*. No particular stage was observed at which the stigma was

specially ready to receive the pollen. It remained sticky right from the bud condition of the flower to the end.

Manurial Experiments.—One-half of the plot received 80 lbs. of poudrette per plant and the other half 40 lbs. in addition to the following artificial manures.

Ammonium Sulphate $\frac{1}{2}$ lb. plus Potassium Sulphate $\frac{7}{10}$ lb. plus Superphosphate $\frac{4}{5}$ lb. = 2 lbs.

The total amount of 2 lbs. was applied in two dressings at an interval of two months. The results have been in favour of the artificially manured plot.

Varieties.—In order to ascertain the suitability of the varieties for the Deccan tract, 57 varieties were planted in the rains of 1917. Of these, Safet-Velchi, Yalakki, Sahasraphali, Mitla, Sugandha, Mysore-bali, Nendra-bali, Parat-bali, Kare-bali and Son-kel have sweet, delicious fruits.

Tutta-bali and Cheena-bali have given the biggest fruits, the former weighing 11 ozs. and the latter 8 ozs. Tundoc and Patta-Madaranga-bali have borne long fruits, the former being 9" and the latter 8" long.

The varieties Son-kel and Walha Rajeli were cultivated on a large scale and the following are the results arrived at:—

Son-kel.—1. The average yield per sucker has been 164 fruits.

2. The yield in the first sucker generation, is more by an average of 59 fruits than that of the mother plant and in the second generation there is a further average increase of 23.

Rajeli.—3. The average yield per sucker has been 79 fruits.

Experiments with sun-drying of fruit of various varieties were conducted from 1918 and it has been shown that nearly every variety can be dried and the common beliefs that the Rajeli is the only variety that can be so dried and that Agashi is the only place where the drying can be done have been

proved erroneous. A simple insect-proof apparatus has been devised to secure a clean product. Fruit dried in this, has actually kept well for about a year. The experiments have been continued especially with a view to secure uniformity of colour and quality of the product.

Grapes.

Experiments on this were carried on from the year 1908, on diseases; varieties, training systems and various aspects of culture, etc. The following results were obtained:—

1. It has been proved that grape vines can be successfully and profitably cultivated in Poona conditions.

2. An improvement of grape vine beds has been made. The Nasik cultivator's method is to have at the foot of each vine a trough 12" deep. This trough is filled with water at each irrigation. We now make rings at some distance from the plant and give water more or less at surface level.

3. We economise water and thus reduce moisture in the atmosphere of the vine-yard and so indirectly help in avoidance of conditions suitable for mildew.

4. The quantity of water required by grape vine plants in the fruiting season is about 300,000 gallons per acre under our conditions of planting.

5. It has been found that the large cuttings or stumps of Pangara (*Erythrina indica*) if planted at the outset along with young vines retard the growth of the latter. The young vines refuse to shoot upwards but remain stunted while the cuttings of Pangara strike root and grow. Therefore, it is a great advantage to drive in the ground near vine soon after planting the latter, slender stakes of wood for the vines to catch hold of, to be replaced later with thick stumps.

6. The "Bucko" hand cultivator has been used for stirring the beds with great success.

7. *Training*.—Training on the single-stake system is more economical than training over-head or on the four-stake system in places where field conditions prevail.

8. Training on the umbrella system has given a yield of 40 lbs. of grapes per tree (one plant yielding 66 lbs. in the year 1919) while one vine trained on the single stake has given a maximum of 19 lbs. of grapes per tree—both trees of the same age.

9. It has been demonstrated in Poona that one grape vine, nine years old, trained on the extensive system on an over-head bower covering an area of about 350 square feet, has yielded 800 bunches of a total weight of about 250 lbs.

10. *Diseases*.—Powdery mildew (*Oidium*) can be successfully combated by 4 to 5 sprayings in the year with Bordeaux mixture. Three of these sprayings should be with normal mixture and two sprayings with half strength. Soft soap is used as an adhesive.

11. The spraying of one acre of vines costs Rs. 22-8-0 and it saves Rs. 200 to Rs. 250 per acre which would otherwise be lost owing to the disease.

12. If the last spraying with Bordeaux mixture of half strength is done in good time before the actual harvesting of the bunches, no stains or only a few faint ones are left on the berries. If the stains are found objectionable, they are easily removed by just dipping the bunches and stirring them in water.

13. There is no danger from poisoning. The worst stained bunches contained an average of .007 grammes of copper in a bunch weighing 152.2 grammes. This means that in order to absorb 0.5 grammes of copper which is the maximum amount that may

with safety be absorbed daily, the consumer would have to eat 25 lbs. of grapes. Thus the excess of grapes would trouble him earlier than any possible copper poisoning. The most economically and carefully sprayed bunches of grapes contained 0.014 per cent. of copper or a minute trace. Considering this quantity as a basis, one must eat 75 lbs. of grapes before even the slightest symptoms of copper poisoning becomes perceptible.

14. The possibility of any permanent staining of the berries is removed by spraying once or twice with the mixture known as Ammonium Copper Carbonate mixture.

15. Potassium Sulphide as a remedy against the disease has not been of any use.

16. The variety Neelam has been found to be mildew-resistant but the quality of the fruit is very inferior. An attempt to cross it with Bhokri (local variety with good yield but liable to the attack of mildew) as a male parent, was done in December 1918 and one successful hybrid has been obtained.

17. *Varieties*.—The varieties, Kandhari and Black Prince have been found to be good yielders with fruit superior in quality to those of Bhokri.

18. Though the Fakadi variety is a shy bearer, its yield can be improved by over-head system of training.

19. Kali-Sahebi, Pandhari-Sahebi and Italian varieties have entirely failed to give any yield.

20. None of the foreign varieties introduced from France and America have given any promising results so far.

21. *Propagandist work*.—The remedy against mildew has been very successfully demonstrated in tracts (Nasik and Ahmednagar) where grapes are cultivated by agriculturists. The demonstrations have been

so effective that practically all the cultivators in Nasik, have taken up the spraying and do it at their own cost as one of the regular routine operations in connection with grape vine cultivation.

22. Sprayers were unknown in the grape growing tracts in 1909. Now almost every cultivator has provided himself with one "Prize bucket sprayer" costing Rs. 16 and a few have bought Knapsack sprayers and Auto-sprayers costing Rs. 60 and Rs. 75, respectively.

Papaya.

Experiments on this conducted since 1909, have indicated the following facts :—

1. The papaya can set fruit without the stimulus of pollen.
2. The seed takes a long time to germinate if sown in the hot or the cold weather and the percentage of germination is also poor. Seeds sown in the rains germinate quickly with an assured high percentage of germination.
3. The Ceylon, Washington and Cujrat papayas have been found to be superior to the local ones, being luscious in taste. The Washington papayas, moreover, last for a day or two longer than the local ones.
4. Thinning the fruits increases their size and prevents crushing of fruits, though it may not pay in every case.
5. The artificial branching of the papaya by cutting of the top, results in low stocky trees and increased number of fruits.
6. Crossings of papaya plants showing different types of flowers were done with a view to produce a race of papaya with a large proportion of female plants.

7. Seeds from fruits of plants having andromonœcious-hermaphrodite flowers generally produce a larger number of bearing plants.

8. Propagation by cuttings has been successful, the percentage of success being about 80. Success depends, however, on the age of the parent branch from which the cuttings are taken and also on the composition of the soil which should consist of river soil and fine sand in equal proportion. This method of propagation eliminates the question of sex entirely.

9. Old and effete papaya trees can be rejuvenated for a year or two more by cutting off the tops and inducing the formation of new branches below the cut portion.

10. The papaya plant is extremely variable with regard to its sexual characteristics. Besides the plants being purely dioecious and monoœcious, intermediate forms are also met with.

The male plants after producing staminate flowers also produce hermaphrodite flowers in some cases which later on are succeeded by pistillate flowers that form small fruits. Sometimes the male plants produce hermaphrodite and pistillate flowers abruptly and unexpectedly.

The monoœcious type of plant produces fruit in every case and has two kinds of flowers, the first staminate and the second perfect. In the axil of each leaf there is usually a single staminate flower and later on a cluster of flowers about $1\frac{1}{2}$ to 2 inches in length which contains at least one perfect flower and one or more staminate flowers. The perfect flower is quite different in shape from the pistillate flowers of the dioecious type. Its ovary is much more elongated, being almost cylindrical; the stamens are usually placed on the inner walls of the petals about midway down with the another surrounding the lobes of the stigma. The

fruit of this type differs from that of the dioecious type in the same way as the ovary and is often called the long papaya.

Guava.

Experiments conducted on this crop since 1909, have elicited the following facts :—

1. It is the belief amongst cultivators that the guava plant if layered for several successive generations will show reduction of the number of seeds in the fruits. This was put to the test and after 8 year's trials in which three layer-generations were tested, it was shown that the number of seeds could not be reduced by this method.

2. The guavas, as a rule, bear flowers in June or July. This flowering is known as the Mrig Bahar flowering. The plants were treated for the Hasta and Ambe Bahar flowerings, by exposing the roots in October and January, respectively. The fruits of the former Bahar were found to ripen in the hot weather and were sweet but are likely to drop down if there be scarcity of water in the wells ; while plants of the latter Bahar yield a small number of fruits. In both cases, the fruits were small in weight and this could be explained as follows :—

The guava has a tendency to bear fruits throughout the year if water is available ; so the energy is not concentrated in any one fruiting season but is distributed.

3. Pruning of guavas for giving shapely plants and improving quality and quantity of fruit was tried from 1916. The results of four years indicate the following :—

(a) Pruned plants flower one month earlier than unpruned plants and set fruits abundantly.

(b) Pruning if practised when the plant is small, produces more vigorous and better shaped plants which are easier to harvest.

(c) Pruning should be done in the months of May or June (if the rainfall of the tract is late) just behind the fruiting part of each branch.

4. Grafted guava plants have so far shown no advantage over plants raised from seed, except that they are more shapely and bushy in the habit of growth.

5. An effective spray for the 'Mahwa' (Aphis) on guava plants has been a mixture of tobacco, soft soap and water in the following proportion :—

Tobacco 2 lbs.	..	} Soak the tobacco in 2 gallons of cold water for 24 hours or boil for half an hour.
Soft soap 1 pint	..		} Dissolve the soap in the mixture.

One part of this mixture and seven parts of water should be mixed and this diluted solution applied as a spray.

6. Of the different varieties of guavas tried, viz., Kothrud, Dharwar, Miraj, Limb, Nasik, Dholka, Sindh-Hyderabad, Allahabad and Lucknow, Sindh-Hyderabad has proved to be the best with regard to taste and less quantity of seeds. The seeds are, moreover, soft. Out of the guava varieties introduced from Saharanpur, the red-fleshed variety grows very well and bears fruits freely but the fruits are not in any way superior to local varieties.

Figs.

1. The plants in calcareous soils are better than those on medium black soils. The poor soils are more suitable for figs than rich black soil. High yield combined with early maturity is obtained in limy soils.

2. The pruning of figs to hasten early fruiting carried on for three years was fairly successful and ripe fruits became available from the month of December, but the cloudy weather, that usually occurs in January, acted as a deterrent for the continuation of the experiment, since a great number of fruits drop down at this time.

3. The foreign varieties of figs failed on account of the dropping of their small undeveloped fruits due to want of caprification.

Citrus.

1. *Stock and Scion experiment.*—In order to ascertain the influence of stock on the scion, buds of all citrus types were inserted on Jamburi (*Citrus medica* var), Mahalung (*Citrus medica* proper), Orange (*Citrus aurantium*) and Reshmi orange (*Citrus aurantium*) stocks and the following are the results obtained :—

(a) Mahalung stock seemed to prefer hardier trees such as Pomelo, Mosambi, Sakharlimbu, Jamburi and also Malta orange having thick and broad bark from large round stems, as scions; Nagpur and Poona Oranges, as also Ladoo and Kawla, were found to grow indifferently on this stock.

(b) If Mahalung preferred some particular scions to others, the Jamburi stock welcomed all. The trees on Jamburi stock were found to be decidedly superior both in height and appearance to those on other stocks. This superiority of the Jamburi stock was to some extent due to its thicker and more elastic bark which is easily separable from the wood below when the sap is flowing. Besides, the bark of Jamburi stock is very mucilaginous and this keeps the scion bud fresh and green for a long time. The bark of Mahalung and oranges is thin and does not separate as easily as that of Jamburi from the inside wood.

(c) The orange stock, when pinched above the budded portion for forcing the buds to grow, often dries up and turns black instead of sending off new shoots. The sap-flowing condition does not last long and the stock does not become fit for budding purposes until it is $\frac{3}{4}$ thick.

(d) Pomelo scions on Mahalung stock have given an average of 15 fruits per tree in their fourth year from budding.

2. *Forcing flowers*.—In order to increase the amount of flowering and consequent fruiting, attempts were made on the following lines :—

(a) Pruning. (b) Bending. (c) Twisting. (d) Ringing.

The following are some of the salient facts obtained :—

All the trees pruned heavily or moderately, put out shoots almost with double vigour.

New shoots came up on the arch formed by bending but did not result in flower production.

Twisting of the branches was found to check new growth but did not result in the formation of fruit buds.

Ringed branches had their parts above the ring killed and presented a yellow head with a green body. Buds below the ring were stimulated at the expense of the growing shoots.

3. Nagpur oranges were found not to thrive well on heavy and clayey soils.

4. Budded plants of Kagdi-limbu have been found to be superior to those raised from seed but owing to thorns in the axils of the leaves the budding operation has been found to be difficult and the percentage of success also has not ranged beyond forty.

5. During the river floods of 1912, many of the citrus plants were submerged in water. Of these, the Mahalung plants were very greatly affected. Leaves on the parts that had been submerged withered and dropped. The twigs bearing such leaves also succumbed in some cases.

6. A large number of citrus crosses were made in January and February of 1912 and 1914. The ovaries swelled

till they reached the size of small pebbles but afterwards dropped down.

7 The Navel Oranges introduced from Saharanpur have not been found to be superior to the Mosambis here.

8. The Jamaica Orange plants were tried here from February 1905. These are vigorous growing plants and their fruits were found to fetch a good price in the Bombay market.

Other Fruits.

Apples and Pears have not been found to ripen their fruits here, though the plants put forth profuse foliage with flowers and small fruits developing.

The Litchi plant was tried here from 1909. These plants had been obtained originally from Behar. The one single plant which is now growing well has not yet fruited though it was planted in the ground in the rains of 1911. The plant requires an artificial shade during the summer as otherwise the leaves get scorched.

Amongst the species of Anonas tried, *Anona cherimolia*, a native of South America and the West Indies, here named "Hanuman-Phal," and introduced from Philippine Islands, has proved a hardy plant yielding fruits more delicious and lasting than its relatives the Custard apple (*Anona squamosa*) and Bullock's heart (*Anona reticulata*.)

The Phalsa (*Grewia asiatica*) plants have given good fruits but the fruits have little market value in the Deccan.

Loquat plants (*Eryobotrya japonica*), though doing well, have no local market value.

Strawberry cultivation was tried only once, in the year 1918, on a small scale, and fair quality of fruit was obtained indicating the possibilities of its cultivation near Poona.

Miscellaneous.

Oporto onions.—Trials of these have been made since 1910. Both seed and bulbs were obtained from Mr. W. S. Millard, Bombay. The trials gave the following conclusions :—

(a) Hot weather sowing was adverse to satisfactory germination.

(b) Seedlings raised from hot weather sowings gave long stem-like bulbs.

(c) Imported bulbs planted in January in very good soil 'bolted' and produced long leafy shoots and stem-like bulbs with no neck.

(d) Bulbs raised from seed introduced in January and planted in November also produced long stem-like shoots.

(e) Attempts to get seeds at the right time always failed, as the seeds arrived too late for sowing purposes.

(f) The onions deteriorated very soon and did not attain the size of their parents except in very few cases.

(g) The object for which the seed was tried, viz., to obtain a large onion, similar to the Portuguese onion, was not attained.

Hedge plants.—A large number of hedge plants were tried since 1909, both under irrigation and also as dry hedges. The following is a brief summary of the results obtained :—

The log-wood (*Hæmatoxylon campechianum*) has been found to be one of the best hedges in forming a dense and impenetrable mass below, if kept pruned, and can thrive well without irrigation. It is easily propagated by seeds and has thorns. It seems well suited to Deccan tracts.

Acacia farnesiana or "Deo Babul" is another good hedge suited to dry localities but does not form such an impenetrable mass at the base as the log-wood.

Inga dulcis, though possessing thorns, does not form a dense mass below. It remains always green if watered.

Lantana camara is not of any use as an impenetrable hedge, as it is deciduous and becomes bare of leaves at the lower portion.

Cæsalpinia sepiaria, though a quick grower, does not get dense below.

Duranta plumerii, remains green and under irrigation forms a thick mass below provided it is kept pruned. Its only defect lies in its not possessing any thorns.

Dodonæa viscosa, is a good ornamental hedge but suffers very badly if inundated and should be planted away from the region of flooding or wherewater does not stagnate.

Crotons.—An experiment done in 1912, to intensify the colour of crotons, has shown that a weekly dose of one oz. of common salt to about three-year old plant and continued for 18 weeks produced vigorous plants and brilliant coloured leaves.

Sprayers.—Amongst the different sprayers used, the Simplex Barrel Sprayer mounted on two-wheeled cart has been found to be useful in spraying big trees such as mangoes, as the spray can reach a height of about 30 feet. The Auto-sprayer of 4-gallon capacity has been efficacious in spraying small sized plants as it effects economy besides being handy.

Miscellaneous.—The following are some items of interest in the garden :—

1. The Cork tree avenue (Photo 3). This presents a beautiful aspect, especially when the edge plants known as spider lilies (*Pancretium littorale*) are in flower.

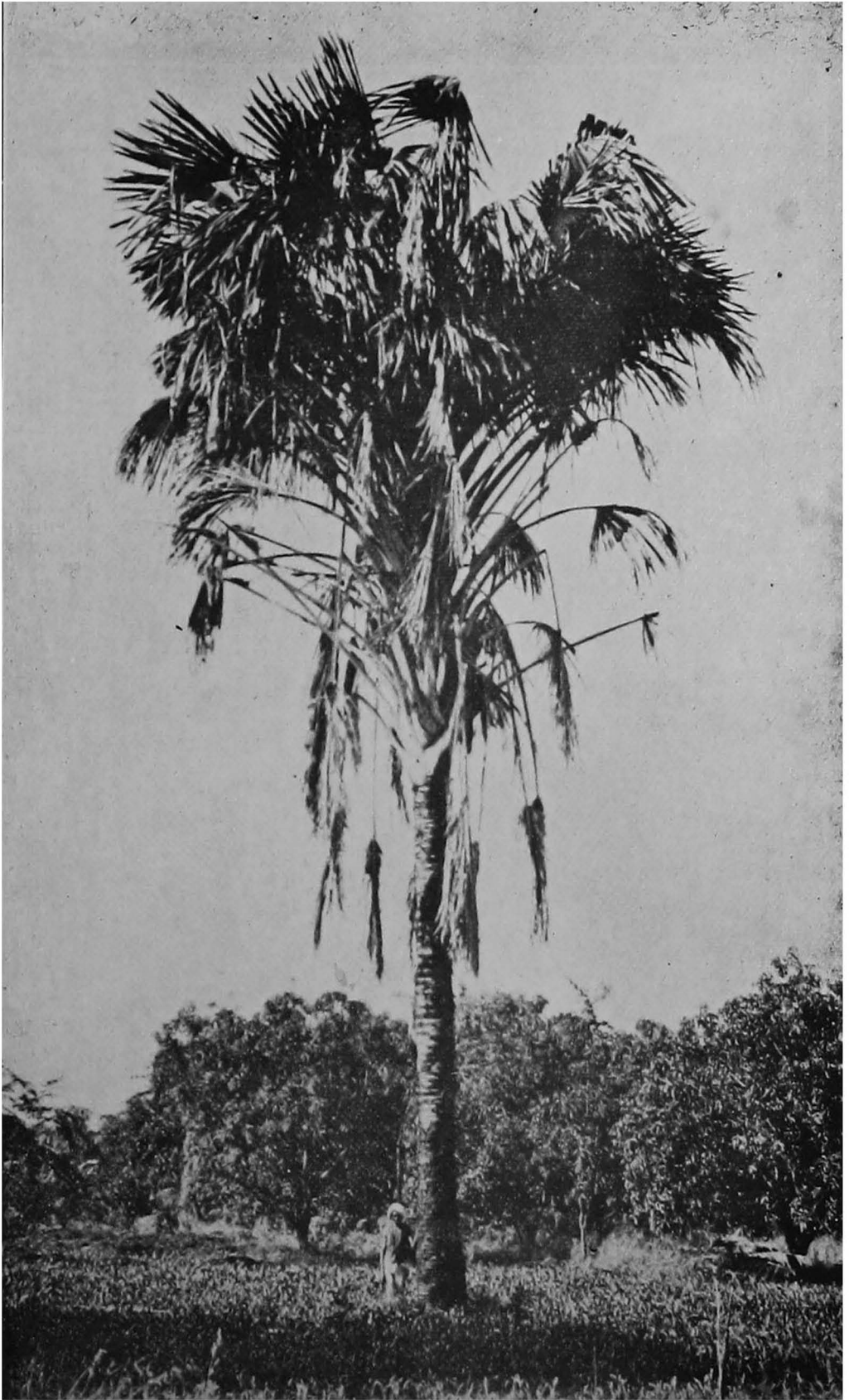


3. THE CORK TREE. (*Millingtonia hortensis*).
Avenue with Spider-lilies bordering the road.



4. THE TRAVELLERS' TREE.

Ravenalla Madagascariensis.



5. THE TALIPOT PALM
Corypha Umbraculifera.

2. The Traveller's tree (*Ravenala madagascariensis* (Photo 4). A remarkably graceful looking tree of Madagascar and planted about 15 years back. The name "Traveller's tree" is on account of the capacity of the tree for storing up water in the receptacles formed by the sheathing bases of the leaf stalks, being thus supposed to be of service to travellers in desert. It seeds freely here.

3. Talipot palm (*Corypha umbraculifera*) (Photo 5). This tree planted about thirty years back has now finished its life-time as it has flowered. It is said that Indians used the leaves of this plant for writing on.

Introduced plants.

The following is a brief summary of some of the plants introduced for economic or ornamental value:--

Name.	Source and date of introduction.	Purpose for which introduced.	Condition and remarks.
Acacia Honstonii (Leguminosae, Mimoseae).	Victoria Gardens, Bombay. October 17th, 1905.	Ornamental plant ..	Has proved to be an elegant flowering plant with red bunches of long bright scarlet stamens; easily propagated by layers.
Allium sativum, bulbiferum. (Liliaceae).	Washington Bureau of Plant Industry. March 10th, 1913.	A variety bearing bulbils in place of flowers.	Bulbils were formed in place of flowers.
Amherstia nobilis (Leguminosae).	Royal Botanic Gardens. Sibpur. 1905.	Ornamental plant ..	No flowers have yet been produced.
Ananasa sativa (Mauritius variety) (Bromeliaceae).	Trivendrum. June 18th, 1914.	Fruit plant ..	Fruit collected on 25th June 1916; small fruit weighing 4 oz. excluding the crown; flavour very good and sweet without irritating sensation found in the local variety; central core not woody as in the local sort; worth introducing in the Konkan.

Anona palustris (Anonaceae.)	Lal-Bag, Bangalore.	Aug- ust 30th, 1910.	Fruit plant	.. Not yet flowered ; plants in vigorous condition.
Antidesma Bunius (Euphorbiaceae.)	Philippine Islands.	Nov- ember 28th, 1912.	The Director of Agriculture, Manila, says "A small handsome tree, dioecious, with simple, dark green leathery leaves. The fruit is small, dark red, sweet, subacid in flavour and produced in long racemes like the currant and may be eaten raw or made into jelly."	.. Not yet fruited ; plant found also wild in the Bombay Presidency.
Brownea Ariza hybrida (Leguminosaeae).	Royal Botanic Gardens, Sibpur.	March 7th, 1905.	Ornamental plant	.. Plant requiring shade ; looks beautiful when in new growth on account of its mottled and drooping green foliage ; not yet flowered ; has been propagated by layers.
Caesalpinia ferrea (Leguminosaeae).	Royal Botanic Gardens, Sibpur.	March 7th, 1905.	Ornamental plant	.. The plant has progressed well and looks graceful with long sweeping branches and yellow flowers. It is now about 20 feet high.

Name.	Source and date of introduction.	Purpose for which introduced.	Condition and remarks.
<i>Cucumis metalliferus</i> . 'horned cucumber' (Cucurbitaceae.)	Kew. Royal Botanic Gardens. 16th November 1913.	Ornamental plant ..	Fruited in July 1914; the fruit is armed with conical rather hard spines 3/8" to half inches long, not edible as it is extremely bitter; requires the same conditions as its ally the cucumber.
<i>Cyperus tegetum</i> (mat grass). Cyperaceae.	Dacca. November 1915.	This gives the material from which Calcutta grass mats are made.	Failed to grow well here.
<i>Drosera indica</i> (Droseraceae).	Badami hills. September 1912.	Insectivorous plant ..	Plants remained healthy for two months when they were washed out by heavy rains.
<i>Durio Zibethinus</i> . (Malvaceae).	Java; Buitenzorg Gardens. 9th January 1914.	Valuable fruit plant ..	Failed to grow even under shade.

<i>Funkia</i> (Liliaceae)	<i>grandiflora</i>	Alipur, Agri. Horti. Society.	Ornamental plant admirably adapted for the lawn, shrubbery, border, and rock work, when grown in pots forms very effective subject for the green house or conservatory.	Progressed well.
<i>Guaiacum officinale</i> (Zygophyllaceae).		Royal Botanic Gardens Sibpur. 7th March 1905.	Ornamental shrub; it also yields a fragrant resin commonly called Gum Guaiacum which is used medicinally.	Flowered in March 1913, with blue flowers; it stands drought well and is a good ornamental plant in the Deccan tracts.
<i>Hibiscus Waimeii</i> (Malvaceae).		Kew. Royal Botanic Gardens. 10th April 1915.	Ornamental plant	Leaves leathery and tough; flowered in June 1916, but does not set fruit unless artificially pollinated.
Hybrid <i>Hibiscus</i> (Malvaceae).		Hawaii.	To see if any blue flowers appear.	Is a hardy ornamental plant with no blue flowers.
<i>Khaya Senegalensis</i> (Bignoniaceae).		Sibpur, Royal Botanic Gardens. 7th March 1905.	African Mahogany, a plant known to be of much commercial value.	Has grown very vigorously and is a very quick grower with an erect stem.

Name.	Source and date of introduction.	Purpose for which introduced.	Condition and remarks.
<i>Kokia rockii</i> (Malvaceae)	Washington, Agricultural Explorer in charge. 18th May, 1915.	A plant closely allied to cotton.	Failed to grow.
<i>Grape-fruit</i> (Rutaceae).	Orange Seeds sent by Mr. G. M. Woodrow in February 1905.	For fruits	Plants growing well, juice scanty and vesicles leathery. The fruit has all the appearance of a pomelo but with a small size; taste like pomelo but without its bitter quality, extremely seedy.
<i>Ipomoea batatas</i> (vineless sweet potato) (Convolvulaceae).	Bureau of Plant Industry. 10th March 1913.	For its vineless nature	Vines of 18" long were first formed on 11th June 1914. The plants remained in good condition for four years.
<i>Mangifera verticillata</i> (Anacardiaceae).	Philippine Islands. 7th October 1912.	The Director of Agriculture Manila, described	Seedlings grew well for three months but afterwards withered.

			the fruit as follows:— The fruit is considerably larger than the mango pyriform, yellowish-green and smooth; the flesh is white and partakes of the flavour of the peach and apricot. It promises to become a valuable addition to our tropical fruits.	
Momordica Cochinchinensis (Cucurbitaceae).	Philippine Islands. 29th November 1912.	Ornamental plant. An attractive climber.	Plant grew vigorously and bore fruits in May 1916. The fruits were oblong, little larger than an orange, having short orange-coloured spines.	
Parkia Timoriana (Leguminosae).	Director of Agriculture Manila. (P. I.) 29th November 1912.	A large soft-wooded roadside ornamental tree. The pods are also said to be relished by cattle and seeds roasted and used as a substitute for coffee by the Philippines.	Plant thriving well; not yet flowered.	

Name.	Source and date of introduction.	Purpose for which introduced.	Condition and remarks.
<p><i>Uvaria purpurea</i> (Anonaceae).</p>	<p>Philippine Islands. 24th October 1912.</p>	<p>A shrubby climber, with bright red kidney shaped fruits having edible sub-acid flesh. The fruiting is also said to be a good ornamental subject.</p>	<p>Progressing well but not flowered.</p>
<p><i>Voandezia subteranea</i>, called Bambara ground nut or Angola bean. (Leguminosae.)</p>	<p>Java</p>	<p>.. High nutritive value ..</p>	<p>To be used as peas in fresh condition, fruit formed close to the ground but not in the soil; seeds have ready market in Bombay; is a native of Tropical Africa.</p>

Wild Fodder Grasses.

A study of these was undertaken in 1911. An attempt was first made to collect all the seeds of the wild grasses and regular experiment was started from 1912. Thirty-four wild fodder plants were in all tried and the following are some of the facts elucidated.

1. The following 12 grasses have been found to be perennial :—

<i>Andropogon annulatus.</i>	<i>Iseilema Wightii.</i>
„ <i>caricosus.</i>	„ <i>laxum.</i>
„ <i>foveolatus.</i>	<i>Chloris barbata.</i> †
„ <i>Monticola.</i>	<i>Cenchrus biflorus.</i>
„ <i>pertusus.</i>	<i>Pennisetum cenchroides.</i>
<i>Ischaemum laxum.</i>	
„ <i>aristatum.</i>	

2. The following have been found to resist drought :—

<i>Cenchrus biflorus.</i>	<i>Andropogon caricosus.</i>
<i>Pennisetum cenchroides.</i>	„ <i>Monticola.</i>
<i>Ischaemum laxum.</i>	<i>Chloris barbata.</i>

3. The following are some of the best grasses suited for hay making :—

<i>Andropogon annulatus.</i>	<i>Ischaemum laxum.</i>
„ <i>caricosus.</i>	„ <i>aristatum.</i>
	„ <i>sulcatum.</i>

4. The following grasses yield more than 8,000 lbs. green weight per acre :—

<i>Andropogon annulatus.</i>	<i>Apluda varia.</i>
„ <i>caricosus.</i>	<i>Anthistiria ciliata.</i>

5. Grasses that yield above 4,000 lbs. per acre (green weight) :—

<i>Ischaemum laxum.</i>	<i>Pennisetum cenchroides.</i>
„ <i>sulcatum.</i>	<i>Cenchrus biflorus.</i>
<i>Iseilema Wightii.</i>	<i>Andropogon Monticola.</i>
„ <i>laxum.</i>	<i>Chloris barbata.</i>

6. Grasses that yield below 4,000 lbs. (green weight):—

Dinebra arabica.	Panicum Isachne.
Eleusine aegyptiaca.	Triachys macronata.
Chloris virgata.	Andropogon pumilis.
Paspalum sanguinale.	

7. Grasses found to be excellent for their feeding value:—

Andropogon annulatus.	Iseilema Wightii.
Panicum Isachne.	Andropogon caricosus.
Cynodon dactylon.	Iseilema laxum.

8. Grasses suited for grazing:—

Andropogon annulatus.	Iseilema Wightii.
„ caricosus.	„ laxum.
„ Monticola.	Ischaemum laxum.
„ foveolatus.	Pennisetum cenchroides.
„ pertusus.	Cenchrus biflorus.
„ lawsonii.	Chloris barbata.

Remarks.— All these grasses are perennial and make a good grazing area after the first cutting.

In order to ascertain how far these grasses would improve the exhausted lands occupied with spear grass (*Andropogon contortus*) trials were done in Government House Compound, Ganeshkhind, from the year 1916, and have led to the following results:—

1. To improve the waste lands, it is at first necessary to burn the existing growth and plough the land.

2. Spear grass (*Andropogon contortus*) can entirely be eliminated within two years and be replaced by good and drought-resisting fodders such as *Andropogon caricosus*, *Andropogon pertusus* and *Andropogon monticola* by cultivation of the land for the first year, reseeding and fencing the area. The area should not be used for grazing until the grasses are completely established. When they are so established after two years, they should be cut in normal years in September and the grasses then left for seeding.

The most important problem of converting the poor Mal land into good pastures and the study of wild leguminous plants with a view to improve the fertility of poor soils by their nitrogen content, is now engaging our attention and work on this is in progress.

Educational.

Apart from the utility of the garden as an experimental centre, its importance as an educational institution is considerable. In this connection it has done much good, as the knowledge imparted to many different grades of men that come here has been of material use in their after-life. The different types of horticultural course conducted here are as follows :—

1. General course: This is one year's course for Malis and horticultural students coming from various parts of the Presidency and also from places outside the Presidency.
2. Special course: This is for a period of 45 days only, with the object of giving special knowledge in plant propagation and general gardening to men who possess previous knowledge in horticulture.
3. Advanced course: This is intended for men taking the optional course of the degree curriculum and also to men taking the regular course and to short-course students of the Poona Agricultural College.

Besides these, an arboricultural class has been held each year since 1915, in the garden for a period of 45 days for the benefit of the sub-overseers of the Public Works Department.

The following statement shows the careers entered by the horticultural students of this garden. No posts are, however, promised. It is understood that one year's course

students, after finishing their course, should go in for private gardening.

<i>Number.</i>	<i>Nature of occupation undertaken.</i>
5	.. Superintendents of different State gardens such as Junagar, Jalwar, Kotah, Rajkot, etc.
6	.. Private gardening.
2	.. Bombay Agricultural Department.
2	.. Malis at State Gardens:
3	.. Service at private nurserymen's gardens.
2	.. Unknown.

Recently, the number of students that come in for one year's course has been increasing, but the want of accommodation has been the limiting factor in their admission.

For some years, students were being trained in the weaving and spinning of eri silk and one of the students was awarded a gold medal by the Industrial and Examination Committee of Yeola (District Nasik) for his proficiency in the art of spinning.

Besides the above, the garden is taken advantage of by the Arts College students for purpose of botanical study. A separate Natural Order plot was laid out for this purpose since 1910, and representative plants of about 38 natural orders have so far been planted. The garden also serves the purpose of an information bureau on horticultural matters to the public and grafted and budded fruit plants, ornamental and road-side trees, whenever available, are supplied to the public.

List of Publications.

Name of the article.	Periodicals or Journals where the articles appeared.	Name of the writer or writers.
	<i>Mango.</i>	
The red rust on mango. ..	Agricultural Coll. Mag., Vol. I, No. 1, 1909.	W. Burns.
The germination of the mango stone. ..	" " " " II, No. 4 1911.	S. H. Prayag.
The inflorescence and flowers of the mango.	" " " " " 1911.	W. Burns and S. H. P.
The Pairi mango. ..	Agri. Jl. of India, Vol. VI, Part I, January 1911.	W. Burns.
The Alphonse mango. ..	" " " " Vol. VIII, Part II, April 1913.	S. H. P.
Mango culture in Goa. ..	Do. do. ..	Do.
Classification of mango varieties. ..	Agri. Jl. of India, Vol. X, Part IV, October 1913.	W. B. and S. H. P.
The grafting of mango inflorescence. ..	Jl. and Proceedings of the Asiatic Soc. of Bengal, Vol. XI, No. I, 1915.	Do.
The vegetative growth of the mango. ..	Bomb. Pre. Science Association, 1913 ..	S. H. P.
The malformation of the mango inflorescence, Paper I.	Do. Aug. 1911.	W. B.

Name of the article.	Periodicals or Journals where the articles appeared.	Name of the writer or writers.
The malformation of the mango inflorescence, Paper II.	<i>Mango</i> —concl'd. Bombay Pre. Assocn., 1912 ..	W. B. and S. H. P.
The sale of the mango crop in the Bombay Presidency.	Agrl. Coll. Mag., October 1915, Vol. VI, No. 2, p. 97.	S. H. P.
A creeping mango ..	Agrl. Coll. Mag., October 1918. ..	G. B. Patvardhan.
The treatment of a mango plantation ..	Bombay Agrl. Dept. leaflet No. 1 of 1912.	
Hints on grafting. ..	Do. No. 4 of 1912.	
The treatment of wounds and cavities of old mango trees.	Do. No. 4 of 1918.	
The Book of the mango.	Bulletin 103 of 1920 ..	W. B. and S. H. P.
Cultivation of oranges and allied fruits ..	<i>Citrus.</i> Agrl. Coll. Mag., Vol. V, No. III, January 1914.	W. B. and H. P. Paranjpye
The cultivation of oranges in Wanvoshi ..	Do. ..	H. P. P.
Jamaica orange, a new citrus fruit in the Deccan.	Do. Vol. VII, No. III, January 1916.	} G. B. P.
An intelligent cultivator's citrus nursery ..	Do. Do. ..	
The experimental renovation of an orange plantation.	Do. Vol. IV, No. III, January 1913.	
The budding of citrus ..	Shetki and Shetkari Vol. III, Nos. 6 & 7.	H. P. P.

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<i>Guava.</i>		
Cultivation of guavas near Poona, Dharwar and Limbgaon.	Bulletin No. 40, 1911.	.. L. B. Kulkarni
Cultivation of guavas in Gujrat ..	Do. No. 79, 1916 ..	L. B. K.
Note on guava cultivation in Gujrat ..	Agri. Coll. Mag., Vol. VIII, No. 2, 1916 p. 96.	L. B. K.
<i>Papaya.</i>		
Variations in the flowers of the Papaya ..	Agri. Coll. Mag., Vol. VII, No. 2, October 1915.	L. B. K.
Observations on the Ceylon Papaya in Poona.	Agri. Coll. Mag., Vol. IV. No. I, July 1912.	L. B. K.
A note on the germination of Papaya seeds	Agri. Coll. Mag., Vol. IV, No. II, October 1912.	G. D. Mehta and L. B. K.
Investigations on Papaya ..	Agri. JI. of India, Vol. IX, October 1914.	L. B. K.
Hints on Papaya cultivation ..	Shetki and Shetkari, 1912, Part 10, p. 225.	Do.
<i>Grapes.</i>		
The first and second year's experiments in the treatment of grape vine mildew.	Bombay Agri. Dept. Bulletin Nos. 36 and 45.	W. B.
Third year's experiments in the treatment of grape vine mildew.	Bom. Agri. Dept. No. 51.	.. W. B. and G. B. P.

Name of the article.	Periodical or Journals where the articles appeared.	Name of the writer or writers.
<i>Grapes—concl'd.</i>		
Grape vine pruning in India ..	Agrl. Coll. Mag., Vol. X, No. 3, March 1919.	G. B. P.
Experiments on grape vine ..	Agrl. Coll. Mag., Vol. IX, No. 4 April 1919.	G. B. P.
Packing of grapes in Ahmednagar for export to out-stations. ..	.. Do. do. ..	G. B. P.
The treatment of grape vine mildew ..	Dept. Leaflet No. 3, 1912. ..	
<i>Bananas.</i>		
The inflorescence and flowers of the Banana, and its wild relative. ..	Indian Science Congress. ..	W. B. and V. G. Mandke and P. J. Dhunbhura.
The drying of Bananas ..	Shetki and Shetkari, Vol. VIII, Nos. 7 and 8. ..	P. G. Joshi.
Do. at Agashi ..	Agrl. Jl. of India, Vol. VI, 1911. ..	L. B. K.
The cultivation of Banana ..	Dept. Leaflet, No. 3, 1915. ..	
The drying of Bananas ..	Agrl. Jl. of India, Vol. XV, Part II ..	W. B. and P. G. J.
Some facts and figures regarding Banana cultivation. ..	Do. Vol. XV, Part IV ..	W. B. and P. G. Dani.

<i>Figs.</i>		
Hints on fig cultivation	.. Agrl. Coll. Mag., Vol. V, No. 3, June 1914.	L. B. K.
Experimental fig drying at Saswad	.. Agrl. Jnl. of India, Vol. III, 1913	.. L. B. K.
<i>General.</i>		
Treatment of the roots of fruit trees	.. Agrl. Coll. Mag., Vol. IV, No. 2, October 1912.	W. B.
Fruit survey in some parts of Saswad Taluka.	Agrl. Coll. Mag., Vol. VIII, No. 3, January 1917.	S. H. P.
A word of advice to fruit growers	.. Agrl. Coll. Mag., Vol. VII, No. 4, March 1916.	L. B. K.
The possibilities of horticulture in Western India.	Agrl. Conference, Poona; September 1913.	G. B. P.
Is fruit growing economically sound ?	.. Agrl. Coll. Mag., Vol. V, No. 4, March 1914.	W. B.
Cocoonut cultivation in some parts of Goa.	Agrl. Coll. Mag., Vol. IV, No. 1, July 1912.	S. H. P.
Rose culture	.. Agri-Horticultural Society Bulletin No. 7, February 1914.	G. B. P.
The effect of frost on plants in G. B. G.	Agrl. Coll. Mag., Vol. II, No. 4, 1911	.. L. B. K.
Further observations on some drought-resisting plants of the Deccan.	Agrl. Coll. Mag., Vol. IV, Nos. 2, October 1912.	G. B. P.

Name of the article.	Periodical or Journals where the articles appeared.	Name of the writer or writers.
<i>General—concl'd.</i>		
Fruit cultivation and fruit industry . . .	Industrial Conference (Karachi) 1913 ..	L. B. K.
Drugs of Sirsi and Kappat hills . . .	Bombay Natural History Society ..	L. B. K.
Hand-list of plants, seeds and bulbs available for distribution in the G. B. Garden.	Bulletin No. 73, 1915 ..	G. B. P.
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Points regarding the selection of grafts for planting.	Agrl. Coll. Mag., October 1916, Vol. III, No. 2.	P. G. J.
Anona Cherimolia . . .	Agrl. Coll. Mag., October 1918 ..	G. B. P.
Influence of stock and scion and their relation to one another.	Science Congress, January 1920 ..	S. H. P.
The top-working of Indian fruit trees . .	Agrl. Jl. of India Vol. XV, Part V ..	W. B. and P. G. J.
Some observations on the roots of fruit trees.	Do. Vol. XV, Part VI ..	W. B. and L. B. K.

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NOTES ON FOREST POLICY AND FOREST
MANAGEMENT

By F. A. Lodge, Esq., C.I.E., Inspector-General of Forests, Hyderabad.

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NOTES ON FOREST POLICY AND FOREST MANAGEMENT

By P. A. Lodge, Esq., C.I.E., Inspector-General of Forests, Hyderabad.

(Reprinted by the Publicity Bureau.)

The First question which arises in connexion with forest policy is: Is the existence of forests necessary or advisable in the interests of a country and its inhabitants? Everybody who travels through a country with his eyes open must realize how extensively wood is used; the peasant's hut cannot be constructed without wood; his agricultural and industrial implements are made almost entirely of wood; wood is the cheapest form of fuel for cooking his food and wood is the material of which his crude furniture is made. Go from the peasant's hut to the rich man's house and wood is still much in evidence; doors, windows, floors, furniture, carriages, etc., show how largely wood is used, and unless the house is within easy reach of a coal-mine wood is the fuel used for cooking and heating purposes.

It must therefore be admitted that wood is necessary in every country and in order that wood may be available at prices within the means of the poorer classes it must be grown within a short distance of the towns and villages in which it is to be utilized. The demand for wood being continuous the supply must be continuous and to insure a continuous supply certain areas must be set aside for the production of wood and if these areas are called forests we arrive at the axiom that forests are necessary for the well-being of every country.

Having laid down the above axiom the next question which arises is: what area of forest is necessary in order to meet the requirements of a country?

Evidently the requirements vary with the density of population and in any given country the requirements a hundred years ago and those a hundred years hence may differ widely from each other and from those of the present day. In a young and undeveloped country there is generally too much forest and its destruction is urged in the interest of the development of the country. But there comes a time when the remaining forests no longer suffice to meet the demands of the country. At what point then should the destruction of forests for the extension of cultivation cease? It may be laid down as a general rule that the destruction of forests should cease when the remaining forest area is just sufficient to meet the requirements of the country. This rule is not absolute, for forests serve other purposes in addition to the production of wood, but it may be taken as representing the minimum forest area required.

Now, how can this minimum area be determined? In other words what percentage of the area of a country should be maintained as forest? The demand for wood varies with the population

and the population varies according to the means of livelihood of the people. A country dependent on agriculture is as a rule more thinly populated than an industrial country; in Belgium, before the war, the population was 658 per square mile; in India it was 158 and in Canada it was 2. Belgium is industrial, India is agricultural, Canada is largely undeveloped. For an agricultural country India is fairly densely populated and although the density of the population will undoubtedly increase let us see how much forest is required to supply wood to a population of 158 per square mile.

Statistics of fuel consumption show that an average family of five people requires from five to ten pounds of wood fuel daily; these statistics were obtained in towns where rigid economy in fuel consumption is necessary and refer only to fuel required for cooking purposes. In villages where fuel is easily procurable the consumption is undoubtedly greater and both in towns and villages a certain quantity of fuel is used for heating purposes during a portion of the year; ten pounds per family per day may therefore be safely taken as the absolute minimum required for domestic purposes. This gives an annual demand of 51.5 tons for 158 people, and it remains to determine what area is required to produce an annual crop of 51.5 tons of wood.

The amount of wood which one acre of land can produce annually depends on various factors of which it is sufficient to mention soil, climate and rainfall. At one end of the scale are the dry deciduous forests on very poor soil which produce only 1/5 ton per acre per annum and at the other the blue gum plantations in the Nilgiris in which the annual growth reaches the enormous figure of 10 tons per acre. After the blue gum the most productive tree is the casuarina which yields 5 tons per acre per annum in suitable localities; but for the purpose of obtaining the average yield of a normal forest these abnormal figures must be excluded. The annual growth of a normal forest in the plains may be said to vary from 1/5 to 1 ton per acre and 1/2 ton may be taken as the average yield. Therefore in order to produce 51.5 tons of wood 103 acres of forest are required. In other words out of every square mile 103 acres or 16 per cent must be set aside for the production of fuel for domestic purposes.

In addition to domestic purposes fuel is needed for a large number of purposes, such as brick kilns, sugar boiling, indigo boiling, charcoal for blacksmiths and goldsmiths, engines in ginning mills, cotton presses, rice mills, etc., and in all village industries in which heat is required.

Wood in the form of timber is necessary for numerous domestic and agricultural purposes and a large number of industries could not exist without it. Its use ranges from match-making to ship-building, from toothpicks to derricks, and its conversion from the rough log to the finished article forms the means of livelihood of a very large number of people.

Minor forest produce in the form of leaves, roots, bark, gums and resins, dyes, fruits and medicines, etc., are in demand for too many purposes—domestic, agricultural and industrial—to enumerate, and although many of these products are yielded in addition

to the main product of trees—wood—some of them require trees or plants to be specially grown for their production.

In some localities forests have to be maintained for purposes quite apart from the production of material; the prevention of avalanches, preservation of sources of water supply, prevention of erosion, moderation of floods, and climatic effect are the most important of such purposes.

The total forest area required for the production of wood, minor produce, and for other purposes, varies in different localities; it could be determined for any given locality in the same way as the area required for the production of domestic fuel has been determined, provided that all the factors of the locality were known, but instead of working out all the complicated details the experience of European countries, in which Forestry has been studied for over two centuries, may be accepted. In France and Germany it was laid down some years ago that for a country to be at its best 25 per cent of its area should be under forests.* The increased productivity of forests resulting from a long period of careful management has caused some experts to reduce this figure to 20 per cent; this reduction however cannot be held to apply to India where the forests have not nearly reached their maximum of productiveness and where the area required for the protection of sources of water-supply is presumably greater than in the temperate climate of western Europe. It may therefore be accepted that in India not less than 25 per cent of the surface of the country should be maintained under forest. The area required may also be determined with reference to the population of the country; the usual allowance is one acre of forest per head of population, and on this basis 158 acres per square mile (640 acres) would be required. The result is practically the same as that already arrived at. It must be pointed out that the question of pasturage has not been dealt with in calculating the forest area required. If pasturage is also to be provided for, a larger area will be necessary, for a given area can only produce a given quantity of material; it may be worked partly for the production of wood and partly for the production of pasture but the total production will remain the same; consequently the two objects, wood and pasture, are antagonistic and either of them can only be increased on the same area at the expense of the other.

A country which has the foresight to preserve from destruction the area of forest necessary for its well-being has a great advantage over a country which has allowed destruction to proceed too far; the reforestation of the French Alps has cost and is costing the State millions of pounds, and the Forestry Committee in England has quite recently recommended the expenditure of £15,000,000 on the reforestation of Great Britain and has calculated that during the war the huge sum of £37,000,000 was paid for wood imported from other countries, which with proper forest management might have been produced in Great Britain itself. This enormous sum, which might have been paid into the British treasury has been paid to the treasuries of foreign countries solely because Great Britain

* In the Madras Presidency only about 15 per cent of the whole country is under forests (vide Appendix A).

has failed, in the past, to maintain the area of forest necessary for its well-being. Countries which still possess a sufficiency of forest may well pause before encouraging the destruction of forests *beyond a certain point* in the endeavour to increase the area under agriculture.

It has been shown that the maintenance of forests is necessary and it follows that somebody must be responsible for their maintenance and management. To whom can this responsibility be entrusted? The private owner's first consideration is the amount of revenue he can obtain from his land, and he will not, unless compelled by law, keep under forest land which will bring him more revenue if placed under field crops; moreover he may, at any time, cut down the whole of his forest in order to realize its value in cash. The Forestry Committee in England has remarked in this connexion that "the owner regards his timber as material which he can convert into cash at pleasure, while the State requires a stock of timber to be maintained in the country."

"Though it may be reasonable enough to require a man to do that which will in all probability bring him profit, he cannot reasonably be required to do that which normally will only bring a return to his successors."

"Forests are a national necessity; the country must have them though they yield less than the current rate of interest on the capital invested."

The authority in charge of forests must be one which will subordinate the question of income to that of permanent maintenance of forests and will consider not only the requirements of the country at the present moment, but its requirements for generations to come. It is evident that the only authority which has a permanent interest in the future is the State and therefore the State is the authority which must be responsible for the maintenance and management of the forest area which is necessary for the well-being of the country. It does not necessarily follow that the State must be the *owner* of the whole forest area; in many countries the law places the forests of private individuals under the control of the State, but as such control may interfere with the disposal of property in accordance with the wishes of the private owner and thus cause friction, it is evident that it is preferable that the State should own all the forests which it controls.

When a State which has for many years encouraged the destruction of forests in order to open out the country, and has allowed the inhabitants to help themselves freely to forest produce from the remaining forests, realizes that the time has come when it must conserve its forests for the good of the country, it becomes necessary to establish an agency to look after them, to prevent further destruction, to regulate fellings and removals, and to maintain and improve their productiveness; this agency is called the Forest Department.

The first thing the Forest Department has to do is to define the area which it has to control. The areas which it is desirable to maintain as forest must be defined in such a manner that they can be easily recognized by the local inhabitants. This means that the boundaries must be clearly marked on the ground and the simplest

method of doing this is by cutting a broad line from point to point of the boundary and marking the points by means of posts, notice boards, stone cairns or heaps of earth.

When a forest has been demarcated by the above means it is generally found that the neighbouring villagers have some complaints to make; some of their fields have been included within the boundary; a sacred temple lies in the forest; inter-village cart-tracks and paths run through the forest. In addition to these claims the villagers have been accustomed for years to graze their cattle in the forest and to help themselves to such timber and fuel as they required.

In justice to the villagers—and to the State—these claims must be inquired into and any legal rights which are proved to exist must either be allowed to continue or compensation for their acquisition must be paid, while spurious claims against the State must be finally disposed of. It is generally felt that Forest officers are too much biassed in favour of their forests to make an absolutely fair settlement of the claims of private individuals and therefore it is usual to appoint a Civil officer as Forest Settlement Officer to inquire into and decide all claims made against Government. The functions of this officer are purely legal; before admitting any claim he must satisfy himself that its existence could be proved in a court of law; he cannot create a right, he can only admit those rights which are proved to exist. It is necessary to emphasize this point because some Forest Settlement Officers pose as philanthropic benefactors of the villagers and attempt to give away Government rights to land and produce which they have no power to dispose of. The commonest instance of this is when villagers claim rights to grazing and wood; such claims can seldom be legally proved, for it can nearly always be shown that they are not *rights* but *concessions* which Government can and does revoke whenever it so desires, but Forest Settlement Officers are inclined to pass orders allowing grazing and removal of wood from the forests. Such orders are *ultra vires*; if a Forest Settlement Officer is of opinion that any *concessions* should be made to the villagers, he may recommend Government to grant them but he cannot himself give away that which is legally the property of Government. It is for Government to decide whether the concessions allowed when there was a surplus of forest shall be allowed to continue when the remaining forest area is insufficient to meet the requirements of the country.

When the Forest Settlement Officer has completed his inquiry and passed orders on all claims preferred before him and when any appeals made against his orders have been disposed of, and when Government has passed orders regarding any concessions recommended by the Forest Settlement Officer or the Forest Department the forest is said to be settled; it is then declared to be reserved forest and is generally placed in charge of the Forest Department for management.

The average layman never seems to realize that there is a limit to the amount of material which a forest can supply; he looks upon the forest as a refuge in time of trouble; if a village is burnt down the villagers must be given wood from the forest to rebuild their

houses ; if famine threatens, the cattle must be allowed to graze in the forests and the poorer classes to earn their living by helping themselves to forest produce and selling it in the neighbouring markets. Even in normal times the layman considers that the villagers should be allowed to enter the forests at will and to help themselves—free of charge and free of control—to whatever they require in the way of wood, also to graze as many cattle as they like. It is however evident that the amount of wood, leaves, grass, fruit, etc., which can be grown on one acre of forest is limited and it follows that the amount which can be grown on a million acres is also limited. A forest must be regarded as an area growing a crop, and just as the ordinary cultivator has to tend, protect and bring to maturity his crop of rice or jowari or cotton, so the Forest Officer has to tend, protect and bring to maturity his crop of forest, but whereas the cultivator's crop matures in a few months, the Forest Officer's crop requires from 20 to 120 years to mature. Who would dream of letting cattle into the cultivator's young crop, or of reaping it before it ripened? The results would be the ruin of the crop and financial loss to the owner. This applies equally to the forest crop, but this is seldom realized and the results are impoverished and disappearing forests. It is evident that if a forest is to be maintained the quantity of material taken out of it annually must not exceed the quantity which Nature puts into it annually, and that if an impoverished forest is to be enriched and made to yield more material than it does at present the quantity of material taken out of it annually must be *less* than the quantity which Nature puts into it annually until the forest is fully stocked, that is to say, until the crop is as heavy as the ground can carry. This then is the Forest Officer's work ; to tend and protect his forest crop ; to improve the productiveness and increase the yield of his forests ; to harvest his crops when ripe and to supply the markets with the maximum quantity of produce which his forests can supply. In doing this he has to look ahead for many years, as his crops ripen but slowly and he has so to arrange matters that he can supply approximately the same quantity of material every year in order to meet current demands. If, for instance, he is growing fuel which matures at the age of twenty years he must have a portion of his forest aged 20 ready to fell this year, a portion aged 19 which will be ready to fell next year, a portion aged 18 which will be ready to fell the year after next, and so on down to a portion aged 1 year which will be ready to fell 19 years hence. It now becomes evident that if in any year fellings extend to areas beyond the portion maturing in that year, the effect is to diminish the supply of some future year. Curiously enough this is the point which the ordinary public fails to grasp. There is a large quantity of immature material growing in the forest and the layman cannot understand why it cannot be cut and utilized at once ; he considers only the requirements of the present moment whereas the Forest Officer knows that he has to safeguard the supply of future years, and so protect and work his forests as to ensure a regular annual supply of material.

Another way of looking at forests is as representing an investment of capital ; a certain sum of money invested in shares will bring in a certain sum as interest annually, but if more than the

amount of the interest is spent the capital is diminished and consequently the interest also diminishes. The forest is the invested capital, the annual growth is the interest; if more than the annual growth is removed in any year it is taken out of capital and the annual yield of following years is reduced. The Forest Officer is in charge of the capital which is invested on behalf of the State, and has to see that not more than the interest is drawn from it annually; he has also to try to increase the capital or to work it in such a manner as to increase the rate of interest which it yields.

The Forest Officer's work is unpopular with the public because it entails the curtailment or abolition of certain privileges to which the public has been accustomed. Haphazard felling and removal of trees is incompatible with proper forest management, so is unregulated grazing, and the restrictions which have to be imposed are resented by the public.

Let us consider the question of grazing; in the Hyderabad State there are large areas called 'rumnahs' set aside specially for the production of grass; these areas are rigidly closed against grazing while the grass is growing and until it has been harvested for the very evident reason that if cattle were admitted the crop of grass would be spoiled. The yield from a good rumnah cultivated and manured, is 1,800 pounds per acre in a normal year; from a poor rumnah on rocky soil it is only 600 pounds; these rumnahs contain no tree growth. In open forest land containing scattered tree growth on morum soil the outturn is 1,000 pounds per acre if the area is closed against grazing, but in some places it is customary to allow grazing for one month after the burst of the monsoon and in those places the *maximum* outturn is 500 pounds; in a bad season the yield may be only one quarter of the above figures. Tree growth prevents grass growth and the denser the forest the poorer the crop of grass. Statistics obtained from fourteen forest areas, recently felled, and therefore containing much less than the normal amount of tree growth, show that from 993 acres 87,927 pounds of grass were collected; this gives an average of 88 pounds per acre; these areas were closed against grazing. These figures show *firstly* that on grass areas the exclusion of cattle is necessary in order to obtain a good crop; *secondly* that under forest the crop of grass is *very* poor; *thirdly* that even in the best grass land a cow (eating 20 pounds of grass daily) would eat the crop off 4 acres in a year while in moderately dense forest the grass on 83 acres would just suffice to feed a cow for a year. Even allowing that cattle can crop the grass closer than it can be cut and thereby double the quantity they can obtain per acre it is evident that only a very limited amount of pasture is available in the forests. What happens when the number of cattle admitted to a forest is greater than the number for which pasture is available? A certain amount of grass is destroyed by trampling and the rest is soon devoured; the cattle then become leaf eaters and the cow-herds lop branches off the trees and cut down young saplings in order to feed their cattle. How can any forest attain a healthy maturity when at all stages of its growth it is subject to such destruction? Apart from the damage done by cow-herds cattle damage forests by trampling on young seedlings or biting of their

heads, and their frequent passage tramples the ground till it becomes too hard for seeds to germinate in it; on steep slopes cattle wear ruts with their feet, and rain-water flowing along these ruts, washes away the soil on which the forest trees depend for nourishment.

It may be laid down as a general rule that in the interests of the forests cattle should never be allowed inside them, but concessions have to be made until the cattle owners have been taught the advantage of providing pasture or other form of food for their cattle on their own lands. In the meantime the forests suffer, but if they are to be preserved from destruction their sufferings must be limited by reducing the number of cattle admitted to the number for which the forests can supply grass.

In this connexion the following extract from the French standard book on forest working-plans dated 1878 is of interest: "In certain localities the working plans have to take into consideration the grazing which takes place in the forests. It is generally of no importance in the broad-leaved forests of the plains of France where the wood produced is valuable and *agriculture is advanced and consequently would make little use of such a wretched method of maintaining its cattle.*"

"But," says the Revenue Officer, "if you deprive the poor ryot of his free wood and his free grazing how is the poor man to live?" In reply it may be pointed out that there are large tracts of country from which forests have entirely disappeared, and in these tracts the poor man has to bear the expense of feeding his cattle, has to utilize the cattle dung—so valuable as manure—in place of firewood, and has to pay heavily for any timber he requires. In such localities the poor man would welcome the existence of forests from which he could obtain firewood and timber, and would willingly pay a moderate price for these necessary articles.

Therefore it is actually in the interests of the poor man that where forests still exist they should be preserved from destruction, and, as pointed out above, this can only be done by protecting them as carefully as the poor man protects his own field crops. The truth is that the poor man has been pauperised by being given certain things free and has therefore never appreciated their value. That he has now got to learn, but in order to make the lesson easy for him, village forests may be established from which he will be able to obtain his wood—not free—but at a low price.

From a strictly legal point of view the poor ryot has no right to a village forest; there are large tracts of country from which all trace of forest has long since disappeared and the ryots have to do without the conveniences afforded by a forest. Allow the destruction of forest to continue, and other tracts of country will be reduced to the same condition and the ryots will not complain, but *so long as a forest exists* it is considered a grievance if Government attempts to prevent its destruction and regulate the utilization of its produce. Therefore, in many countries, Government hands over certain portions of its forests for the use of the villages, and these portions are called village forests. But experience has shown that if these forests are left entirely to the mercy of the villagers they rapidly disappear; the present generation eats them up

regardless of the requirements of future generations. The State is responsible for the maintenance of these forests in the interests of the future and therefore has to control their working and see that the present generation does not diminish the invested capital. In other words the village forests have to be managed just as carefully as the State forests, the only difference being that the produce of the village forests belongs—subject to payment of the cost of management—to the villagers, while the produce of the State forests belongs to the State. The gift of a village forest is a generous act on the part of the State and care must be taken to limit the extent of the gift to the area of forest necessary to supply the actual domestic requirements of the village.

It is a question whether such gifts are necessary or whether the requirements of a village could not be equally well met by allotting to it a fixed quantity of the material to be felled annually in the State forest, payment being made at a low rate to cover actual expenses. This system avoids the inconvenience of cutting up forest areas in order to provide village forests, the multiplication of boundary lines and the evils of dual control, and enables the State to apply the same system of management to the whole of each block of forest.

The question of village grazing areas must be considered quite separately from that of village forests, for, as stated above, the production of wood and the provision of grazing are antagonistic; the same area cannot be used to the best advantage for both purposes.

If forests are to be properly managed free grants must practically disappear. This system of relief has always been popular with Revenue Officers because it is so easy to give what does not appear in the accounts and for which no financial sanction is necessary. But forest produce represents money in another form and the country would get a better idea of what its free grants cost it if they were made in money with which the grantees could purchase the forest material they require. Probably free grants would be more sparingly made if they were subject to check in the treasury and publication in the annual financial returns.

Apart from this point of view it must be remembered that in forests under regular working the interest on capital, that is the annual growth, is being removed annually; it is generally purchased by contractors who are under no obligation to satisfy the demands of free grantees. The rest of the forests is immature growth and fellings in it amount to reduction of capital which is detrimental to the working of the forests. Free grantees cannot be allowed to fell in the immature forests and they cannot obtain their requirements free from the purchasers of the mature forests; but if they obtain a free grant of money they can buy what they require in the open market.

Free grants are an indication that a certain stage in forest conservation has been reached. Starting with a forest-clad country we have first the stage in which the destruction of forests is encouraged in order to open up the country; during this stage the cultivator obtains his wood, leaf-manure, grazing, etc., free of charge and free of control; next comes the stage when the rapid clearance

of forest causes alarm in the mind of Government which takes steps to prevent further destruction and to form a forest estate by reserving certain forest areas: by this time the cultivator has become so used to obtaining free wood, grazing, etc., that he considers that he has a right to it; a compromise is arrived at by leaving a certain area of forest unreserved in order to meet the demands of the cultivators, and by regulating these demands by means of free grants. The third stage shows the reserved forests brought under regular management, the growing and harvesting of the forest crop receiving as much attention as that of any other crop, while the growth on the unreserved areas gradually disappears and the cultivators gradually learn to pay for the wood they require and to provide pasture or food for their cattle at their own expense. During this stage free grants gradually disappear.

The fourth and last stage is the natural development of the third stage; no unreserved forests are left, the reserved forests are supplying annually as much wood, etc., as they can produce, and the cultivator has realized that he has no claim over these forests and has learned to pay for his forest material just as he does for his clothes and all his other requirements. Even if a generous Government has allowed some of its forests to be constituted village forest the cultivator still has to pay a certain sum for his wood because even village forests cannot be protected and worked without some expense, and this expense has to be met by the sale of the annual crop. In the countries of Western Europe the final stage has been reached and the Forest Department is no longer unpopular, for the population realizes the enormous benefits conferred upon it by the presence of forests which, but for the action of the Forest Department, would long ago have ceased to exist. Not only do the forests ensure a regular and cheap supply of timber and fuel, but also they provide means of livelihood for a considerable percentage of the population, partly in tending and harvesting the forest crop, and partly in the numerous local industries which depend for their existence on a cheap supply of wood or other forest produce.

India has not yet reached this stage but the Forest Department is steadily fighting its way—frequently encountering much opposition—towards it, knowing that when it is reached the country will obtain from its forests the maximum benefits which they are capable of yielding.

APPENDIX A.

Extract from the season and crop report of the Madras Presidency for the year 1918-19.

Name of district.	Area in acres of					
	Forests.	Other porambokes.	Unoccupied cultivable wastes.	Occupied land left waste.	Cultivated land.	Total.
Ganjām ...	454,124	2,098,294	836,779	307,308	1,669,082	5,365,587
Vizagapatam ...	656,871	5,077,118	2,251,903	830,047	2,183,299	10,999,238
Godāvāri ...	844,836	1,570,307	231,782	438,917	894,856	3,980,698
Kistna ...	169,577	530,598	436,922	596,928	1,687,637	3,421,662
Guntūr ...	515,609	396,410	206,809	498,849	2,031,094	3,648,781
Nellore ...	467,610	1,750,354	744,627	908,901	1,231,561	5,103,053
Kurnool ...	1,658,884	281,467	586,107	379,324	1,900,918	4,806,700
Bellary ..	386,216	319,956	333,314	426,346	2,183,181	3,649,513
Anantapur ...	482,064	490,689	1,166,296	719,220	1,423,571	4,281,840
Cuddapah ...	1,158,203	566,077	671,884	365,686	962,845	3,724,695
Chittoor ...	529,550	1,379,303	784,138	337,501	559,883	3,590,375
North Arcot ...	795,404	749,658	222,222	385,358	1,018,292	3,170,934
Chingleput ...	132,229	605,306	176,783	296,820	685,754	1,896,892
Madras ...	...	17,210	...	...	...	17,210
South Arcot ...	179,516	712,960	165,800	397,295	1,228,924	2,684,495
Salem ...	956,613	881,156	536,286	532,653	1,517,245	4,423,957
Coimbatore ...	1,490,092	302,409	259,828	629,052	1,946,618	4,627,999
Trichinopoly ...	158,363	449,456	320,633	500,037	1,339,196	2,767,685
Tanjore ...	8,956	661,413	168,595	337,778	1,212,661	2,389,403
Madura ...	422,341	612,006	416,482	342,999	1,367,507	3,161,335
Rāmnād ...	46,724	321,900	203,651	205,344	1,460,353	2,237,972
Tinnevely ...	229,071	562,036	43,731	625,975	1,304,902	2,765,715
The Nilgiris ...	333,347	49,120	70,902	121,906	75,942	651,217
Malabar ...	356,873	927,182	1,006,874	65,753	1,352,005	3,708,687
Anjengo ...	...	32	7	...	336	375
South Kanara ...	511,295	689,153	503,851	337,007	532,164	2,573,470
Total ...	12,944,868	22,001,570	12,346,206	10,587,014	31,769,826	89,649,484

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FACTS

FROM THE

COAL

COMMISSION

COMPILED BY

R. PAGE ARNOT

(SECRETARY LABOUR RESEARCH DEPARTMENT)

FOR THE

MINERS' FEDERATION OF GREAT BRITAIN,

WITH A FOREWORD BY

**ROBERT SMILLIE AND
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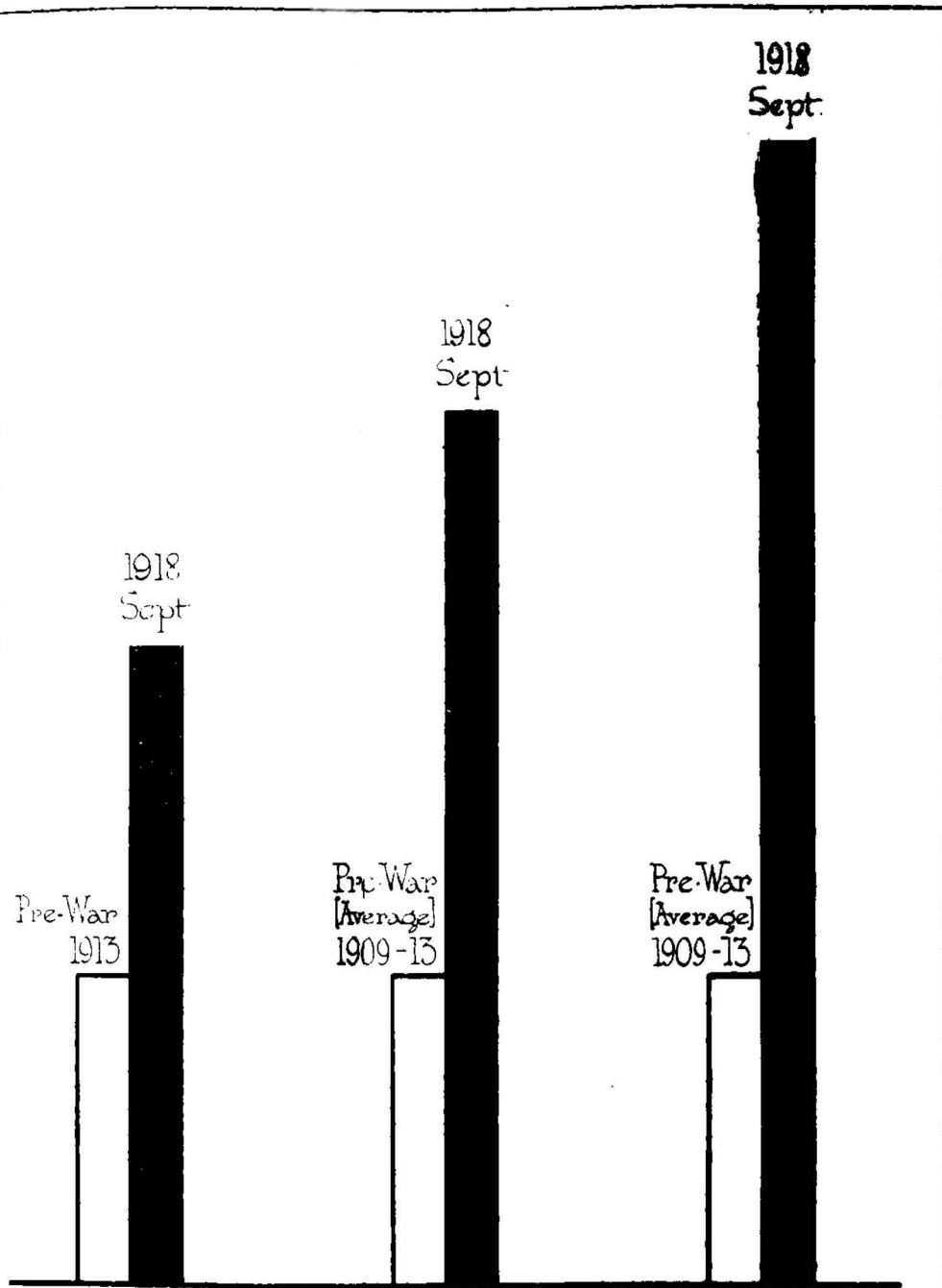
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MINERS' WAGES

£82.- - £169.

COAL PRICES

[Pithead] per ton.
8/9 - 24/10

OWNERS' PROFITS

Per ton.
11½ - 37/6½

DIAGRAM SHOWING PRE-WAR
WAGES PRICES & PROFITS
COMPARED WITH 1918

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FOREWORD.

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The Coal Industry Commission has completed the first chapter of the Domesday Book of the Coal Mining Industry of Great Britain.

There are other chapters to be written. As the first was in the process of being produced, the public mind was aroused and excited as rarely before on grave economic problems. The Press from day to day gave much publicity to the work of the Commission, and often this publicity resolved itself into sheer sensationalism, for the evidence submitted was frequently of a sensational character. Whilst this form of public excitement was at its height, it was felt that some permanent record should be produced which would set forth the facts of the case, and which might be a great source of help and inspiration to the working classes after the first symptoms of public interest had passed away.

It was felt that in this case, as in the case of a great explosion in a coal mine, public sympathy would soon be diverted from the channels of esteem for the coal miners, their work, their important function in the State, and the social conditions under which they live. That the public would soon complacently forget that there were such beings as coal miners until either by another awful explosion or by the threat of a national strike the fact was brought harshly home.

Consequently, it was deemed advisable that this record should be written up. It will be found to make more interesting reading than the official Blue Book report of the proceedings when available for the public.

This little work offers meagre commentary, if any, upon the facts as stated in evidence. The facts themselves are sufficiently eloquent. Their language is easily understood. Their words expose in a lurid light the economic rottenness of the present system of capitalistic ownership of one of our greatest national assets. Comment is rendered superfluous.

Mr. Page Arnot, who was kindly lent to us by the Labour Research Department, has performed a useful and important task in producing this document. The style and clearness of statement, combined with the logical arrangement of the evidence, makes the work a valuable one. It should be read by every member of the public, as well as that portion represented by the industry itself.

The Coal Industry Commission has scarcely commenced its work. Its greatest and most important tasks lie before it. Nationalisation, effective control by the producers whether by hand or brain, economies in production, elimination of waste, maximum economic value of the product for the community, with maximum social amenities for the men who produce the commodity—coal. These are the ends for which the Commission must now work. These represent the aspirations of the toiling millions. They must be realised.

ROBERT SMILLIE.
FRANK HODGES.

55, Russell Square, W.C. 1
April 21st, 1919.

CHAPTER I.

INTRODUCTION.

1.—Origin of the Coal Commission.

A well-known English author commenting in an American paper on the industrial events of March, 1919, has alluded to it as one of the most remarkable months in English history. Certainly, it would not have seemed possible in normal times that a Commission could be set up with the extraordinary powers, wide scope, and unique personnel of the Coal Industry Commission, or that the big vested interests would have tolerated such an inquisition into the private ownership of capital.

The Southport Resolutions.

We may ask what made it possible for this to happen? The answer is to be found in the history of the negotiations between the Government and the Miners' Federation of Great Britain. As far back as January 9th of this year the Miners' Executive had put forward their claim for a 30 per cent. advance in wages. At a Miners' Conference held at Southport in the middle of January this claim was reaffirmed, though the feeling was strongly entertained that an advance of 50 per cent. should be asked for, and it was also decided to ask for

- (a) Full maintenance for demobilised and unemployed miners.
- (b) An amendment of the so-called "Eight Hours Act" to read "six" for "eight" (which would really be a seven hours day).
- (c) Nationalisation of all mines and minerals (which by an earlier conference included control by the workers as a part of any scheme of nationalisation); together with the
- (d) 30 per cent. advance on earnings, exclusive of war wage (3s.).

After unsuccessful negotiations with the Government had taken place (the Government offer was a Committee of Inquiry and a shilling a day solely to meet the rise in the cost of living), the miners' conference in the middle of February decided to take a ballot vote of the membership on the question of a stoppage of work to secure their proposals.

Premier Meets Miners at Downing Street.

On Friday, the 21st of February, in response to an invitation, the Executive Committee of the Miners' Federation met the Prime Minister at 10, Downing Street. The proceedings resolved themselves in the main into a speech by the Prime Minister and a statement in reply by Robert Smillie. The Prime Minister submitted that the miners should delay for a fortnight the expiry of the strike notices (which were dated for 15th March), and should participate in a Commission which would be bound to present an interim report by the 31st March.

Mr. Smillie's Reply.

Mr. Smillie, in a moderate but strongly reasoned reply, reminded the Government that the miners' wages claim had been lodged as far back as 29th January. He showed that the claim, having been reduced to the lowest possible, was just and fair from every point of view. He dwelt on the miners' housing conditions and the other conditions of his working life. He said—

"The mine-owners have always told us, and you tell us now, if you had the mines back to them for free competition amongst each other, that we have no right to a voice in the working conditions in the mines—no voice on the commercial side at all. They say: 'We invested our money in those mines and they are ours; you are merely our hands.' Now, I say we invest our lives in those mines, which is of greater importance than the capital of the employer; and to that extent I have a right to have a say as to what the conditions shall be, not merely the working conditions, but we are entitled to have some information on the commercial side of the industry also. I believe, sir, that you have the data at hand, if you cared to use it, to be able to give us a reply on the wages question as to whether or not the claim which we put forward is unreasonable."

Finally, he said that the wages and hours claims, on which the information for decision was already in the hands of the Government, could be dealt with immediately, and need not stand over until a Commission reported. The Prime Minister refused this, and again said that these matters must be remitted to the Commission. He suggested that miners might serve on such a Commission. The Executive Committee then agreed to call a Conference to consider whether or not the miners should participate.

Result of Strike Ballot.

Five to One Majority.

Meantime, the result of the ballot vote had become known, and Mr. Lloyd George had agreed that the interim report of the Commission should be published by 20th March. The ballot showed a majority in favour of a stoppage of over half-a-million, the actual figures being (February 25th):—

For stoppage.....	615,164
Against stoppage	105,082

Majority for..... 510,082

The Conference Decides to Participate in Commission.

The Conference of the Miners' Federation met on the 26th in London, and after a day's discussion adjourned. Strong arguments had been presented against participation, on the ground that if the report was adverse, the miners' case would be prejudiced. On the 27th, however, it was decided to participate, but only on strict conditions as to the miners' representation. It was also agreed to postpone strike notices till March 22nd. Eventually an understanding was reached that the miners should appoint four representatives directly, and that the other two representatives on the workers' side should be mutually agreed upon between the miners and the Government, but formally nominated by the latter. Accordingly, about 1st of March, the Commission was made up as follows:—

Hon. Mr. Justice SANKEY (in the chair).

Labour side:—

Mr. ROBERT SMILLIE, Mr. HERBERT SMITH, Mr. FRANK HODGES, Sir LEO CHIOZZA MONEY,	} Appointed by the Miners' Federation.
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Mr. R. H. TAWNEY, Mr. SIDNEY WEBB.	} Agreed upon between Government and Miners' Federation.
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Employers' side:—

Mr. ARTHUR BALFOUR, Sir ARTHUR DUCKHAM, Sir THOMAS ROYDEN,	} Govern- ment nominees.
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Mr. EVAN WILLIAMS, Mr. R. W. COOPFR, Mr. J. T. FORGIE.	} Represent- atives of Coal- owners.
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2.—Proceedings of the Coal Commission.

The Coal Industry Commission held its first meeting on March 3rd, when it settled the method of procedure. By what can almost certainly be ascribed to the sound strategy of the Labour side of the Commission, it was decided to call Government witnesses first, thereafter representatives of industries immediately dependent on the coal industry, then coal owners' witnesses, and finally miners' witnesses.

The public examination of witnesses began on Tuesday, 4th March, and concluded on Monday, 17th March. The Commission sat every day, except Sunday, and met several times in private, and, after the 17th, deliberated entirely in camera until the report was ready.

REVELATIONS OF PROFITEERING.

The first witness called was the Financial Adviser to the Coal Controller. The revelations disclosed by him of the profiteering in coal during the war caused an immediate revulsion of public feeling in favour of the miners and against the coalowners. By the evidence of the witnesses who followed, it became clear that the private ownership and distribution of coal had not merely meant swollen profits wrung out of the low wages paid to the miner and high prices paid by the public, but had also seriously hampered the national effort during the war by its inefficiency and wastefulness.

By the end of the first week, under the cross-examination of the Labour side, it had become obvious that the case for private ownership had gone by the board. This applied not merely to the ownership of mines and minerals, but to the private control of distribution, both wholesale and retail. Further, it was seen that the economies to be effected under nationalisation were in themselves sufficient to meet any extra cost entailed by granting the miners' claims. It was with a certain surprise that the public, and perhaps some of the miners, realised that nationalisation provided the only really adequate method by which to preserve and raise the miner's standard of life, besides being the only effective safeguard for the consumer.

The Capitalist Witnesses.

The evidence presented by representatives of various capitalist interests purported to show that the effect of the miners' claims would be ruinous to industry. These arguments, however, weakened under cross-examination, and particularly when the witnesses were confronted with the broadly human aspect of the miners' claim for a higher standard of life.

Miners' Witnesses.

The witnesses for the Miners' Federation were examined on Friday and Saturday, 14th and 15th March.

These were .—

	Subject.
W. STBAKER (Northumberland)	Nationalisation.
J. ROBERTSON (Scotland).....	Standard of Life (Housing, Health, Education, Accidents, etc.)
J. POTTS (Yorkshire).....	Hours and Output.
VERNON HARTSHORN, M.P. (South Wales)	Wages.

In each case the miners' point of view was ably stated and sustained under severe cross-examination from the coalowners' side of the Commission. Mr. Straker in particular, who had submitted draft provisions indicating the sort of control of the industry which the miners desired as part of any nationalisation scheme, was kept in the witness box all day, while Mr. Robertson's evidence on the abominable housing conditions in mining villages undoubtedly made a very deep impression both on the Commission and on the public. The subjects of wages and hours had already been dealt with partially by previous witnesses, but here, too, the evidence of Mr. Potts and Mr. Hartshorn was of marked utility to the inquiry.

The public sessions closed on Monday, 17th March, with evidence from co-operative societies and others, the effect of which was to reinforce the impression of the opening sessions, that private ownership in the production and distribution of coal was characterised by wastefulness and extravagance.

THE THREE INTERIM REPORTS.

It was found impossible to present a unanimous report, and eventually, on March 20th, three reports were presented, first, the Majority Report; second, a Report signed by the Chairman and three other members; third, a Report signed by the three coalowners.

THE MAJORITY REPORT.

This was signed by Messrs. R. Smillie, Frank Hodges, and Herbert Smith, Sir Leo Chiozza Money, Messrs. R. H. Tawney and Sidney Webb. The following is the summary of their conclusions:—

1. We find that the miners' claim to an advance in their standard of life is justified; and that the percentage of rise of wages asked for, namely, 30 per cent. (on earnings apart from war wage), is not excessive.

2. We find justified the claim to a substitution in the Coal Mines Regulation Act of 1908 of six for eight (making the future maximum working day underground vary from about six and a-half hours in some mines to eight and a-half hours in others, and averaging nearly seven hours). A corresponding shortening of the working day should apply to the surface workers.

3. We find justified the miners' claim for a more efficient organisation of their industry—the individual ownership of collieries being officially declared to be "wasteful and extravagant," whilst the method of retail distribution is unnecessarily costly; and in view of the impossibility of tolerating any unification of all the mines in the hands of a capitalist trust we think that, in the interest of the consumers as much as in that of the miners, nationalisation ought to be, in principle, at once determined on.

4. As to the claims in respect of miners demobilised from the Army, we think that it would be better for these to be dealt with along with the cases of men in other industries.

These conclusions were buttressed by several pages of closely-reasoned argument, illustrated by facts brought out in evidence.

THE SANKEY REPORT.

This was signed by the Honourable Mr Justice Sankey (Chairman), Mr Arthur Balfour, Sir Arthur Duckham, and Sir Thomas Royden, Bart. Its main recommendations as to wages and hours were as follows.—

1. We recommend that the Coal Mines Regulation Act, 1908, commonly called the Eight Hours Act, be amended by the substitution, in the clauses limiting the hours of work underground, of the word " seven " for the word " eight " as and from July 16th, 1919, and, subject to the economic position of the industry at the of 1920, by the substitution of the word " six " for the word " eight " as and from July 13th, 1921. Certain adjustments must be made in the hours of the classes of underground workers specifically mentioned in the Act.

2. We recommend that as from July 16th, 1919, the hours of work of persons employed on the surface at or about collieries shall be 46½ working hours per week, exclusive of meal times, the details to be settled locally.

3. We recommend an increase of wages of 2s. per shift worked or per day worked in the case of the classes of colliery workers, employed in coal mines, or at the pit-heads of coal mines, whose wages have in the past been regulated by colliery sliding scales. In the case of workers under 16 years of age, the advance is to be 1s.

4. We recommend the continuation of the Coal Mines Control Agreement (Confirmation) Act, 1918, subject to certain suggestions indicated in our report.

Further important recommendations dealt with nationalisation, control of industry by the workers, and housing conditions. The salient passages may be quoted:—

" Even upon the evidence already given, the present system of ownership and working in the coal industry stands condemned, and some other system must be substituted for it, either nationalisation or a method of unification by national purchase and/or by joint control."

" We are prepared, however, to report now that it is in the interests of the country that the colliery worker shall in the future have an effective voice in the direction of the mine. For a generation the colliery worker has been educated socially and technically. The result is a great national asset. Why not use it? "

" Evidence has been placed before the Commission as to the housing accommodation of the colliery workers in various districts. Although it is true that there is good housing accommodation in certain districts—and to some extent—there are houses in some districts which are a reproach to our civilisation. No judicial language is sufficiently strong or sufficiently severe to apply to their condemnation."

" It is a matter for careful consideration whether a 1d. per ton should not be at once collected on coal raised and applied to improve the housing and amenities of each particular colliery district.

A 1d. per ton on our present output means about £1,000,000 a year."

Finally, it was suggested that when the Commission met again it should continue to make interim reports containing suggestions which could be immediately acted upon by the Government.

The Coalowners' Report.

This report was signed by Messrs. R. W. Cooper, J. T. Forgie, and Evan Williams. It was confined solely to wages and hours, and its recommendations were:—

1. One and sixpence per day for persons 16 years of age and upwards, 9d. for persons under 16.
2. A substitution of "seven" for "eight" hours in the Eight Hours Act.
3. Eight hours per day for surface workers.

THE GOVERNMENT ADOPT THE SANKEY REPORT.

On Thursday, 20th March, these three Reports were presented to Parliament. The same evening Mr. Bonar Law announced that the Government had adopted the Sankey Report "in spirit and in letter." Unfortunately he also saw fit to say that if a strike took place "the Government would use all the resources of the State without hesitating," a threat which was at once resented by the Labour Members.

The Federation Conference.

Friday, 21st March.

The meeting of the Miners' Conference, held in London on 21st March, after considerable discussion decided to recommend the districts (whose strike notices expired the following day) to continue working on day to day contracts until Wednesday, 26th March, and meantime that the Executive should negotiate with the Government with a view to securing a modification of the Sankey proposals.

Saturday, 22nd March.

On Saturday, March 22nd, various points were urged before Mr. Bonar Law, who promised that he would give a reply by Tuesday, 25th March. On the Tuesday, the representatives of the miners again met Mr. Bonar Law and Sir Robert Horne. Mr. Law announced, on the points put before him, that the Government could make no substantial change in the terms of the Sankey Report, which they had adopted as a whole. His general attitude, however, was conciliatory, and on the questions of "the bonus turn," "piecemeal wages," and retrospective payment of the 2s. per day, agreement was reached.

Mr. Smillie, in reply, restated the arguments of the miners, and while agreeing that the continuation of the work of the Coal Commission might mean the beginning of a new era, said that the Federation Conference must decide on the proposals.

Federation Conference, Wednesday, March 26th.

At the Conference of March 26th, it was decided to take a ballot of the members as to acceptance of the Government proposals, the form and other arrangements of the ballot to be drawn up by the Executive, and the districts, meantime to continue on day to day notices, and to recommend acceptance of the Government's proposals. The Executive Committee afterwards met and decided that the dates on which the ballot should be taken would be 9th and 10th April, the results to be in the hands of the Secretary by the 14th.

3.—General Survey.

The securing of this Coal Industry Commission may be considered one of the greatest achievements in the history of the Labour movement in any country. It is an object-lesson in the use of industrial power. For it is true to say that there has never been a Commission like it anywhere. Never before have we had a Commission on which Labour had half the representation. In this Commission it had really something more than half in effect, for it is no discourtesy to the employers' side to say that they were overmatched by the personalities on the Labour side. Mr. Smillie, Mr. Hodges, and Mr. Smith were all men who combined a practical knowledge of mining with a thorough acquaintance both with the economics of the coal industry and also with more general questions of public policy, and, in the case of Messrs. Smillie and Hodges, there was added to this a dialectical ability as keen as that of any barrister. In Sir Leo Chiozza Money and Sidney Webb the miners had secured two of the foremost champions of national ownership as against private capitalism; while Mr. Tawney, though less famed as a controversialist on these particular questions, proved to have an urbane and most effective manner for extracting evidence from witnesses. Against this team the owners' side could do but little. The result was that as the Commission proceeded it became less and less of a cold inquiry, and took on the aspect of an open trial of private capitalism in the coal mining industry. Indeed, from a constitutional point of view, its method of appointment was so anomalous that it is no wonder if its procedure was quite as startling.

The Coal Commission has already shifted the balance of opinion in favour of the miners. It has done this with scant evidence—hastily compiled and incomplete—without any full use of its powers to compel disclosure of all facts and documents; and with only the briefest examination of the profits of individual companies. When it resumes (as it will do unless there is a majority for a strike) it will be possible for it to conduct the most exhaustive examination into private capitalism in a basic industry that has ever been attempted in any country. **And provided the examination is thorough enough—as it will be in this case—the principle of private ownership will give place to the principle of nationalisation on the 20th of May.** For this is a time when the miners may find and publish the truth about the mining industry, and the truth will be the strongest advocate they can have.

CHAPTER II.

THE COST OF PRIVATE CAPITALISM.

PROFITS.*

The total of profits and royalties of the coal mining industry (not including the total of profits from coke-ovens and by-product works) in the five years 1914-1918 amounted to

£160,000,000

—which is 25 million pounds more than the total pre-war capital of the industry (£135,000,000). (See evidence of Dr. J. C. Stamp, Assistant Secretary to the Board of Inland Revenue.)

Profits, etc., Pre-war and Present.

These profits increased enormously during the war, as is seen by the following table, which also shows the tonnage raised, the pithead price, and other figures, both for the pre-war period and for each year during the war.

	Tonnage raised (millions).	Pithead price (per ton).	Profits and royalties.		Persons employed.	Yearly earnings per person employed.
			Amount (millions).	Per ton.		
Average of 5 years to		s. d.		s. d.		£
1913	270	8 9	£19·1	1 5½	1,048,956	82 (1913)
Year .....1914	265	10 0	21·5	1 7½	1,034,105	79
"1915	253	12 6	27·4	2 2	939,604	105
"1916	256	15 7	43·8	3 5	984,796	127
"1917	248	16 9	33·7	2 8½	1,006,299	129
January to June, 1918 (on annual basis)	236	20 0	26·	2 4½	966,355	149
July to September, 1918 (on annual basis)	218	24 10	45·	4 0½	929,524	169

In this most important table, of which some of the figures were only disclosed under the exceptional powers given to the Commission, the following points should be noticed:—

(i.) The pithead price represents the value at the pithead. The price to the ordinary consumer is very much greater (in London nearly double). This is due to middlemen and their costs and charges.

(ii.) The fall in tonnage raised is due, of course, to the enlistment of miners. The "get" per person employed actually rose in 1915 and 1916 from the beginning of the war.

* When not otherwise indicated, these figures are taken from the evidence of Mr. A. Lowes Dickinson, Financial Adviser to the Coal Controller.

(iii.) PROFITS AND ROYALTIES.—Royalties amount to about £6,000,000 per year, or about 6d. a ton. If we knock off this sum from each year it appears that the net profits were:—

	Total (millions).	Per ton. s. d.
Pre-war average (1909-13)	£13 ...	0 11½
July to Sept., 1918, on annual basis	£39 ...	3 6½

Note.—Profits from coke ovens and by-product works, which were not under the Coal Control, are not included in the 1918 figures, though during the war they increased "very considerably" [Mr. Dickinson Q.56]. They are estimated at 6d. a ton additional profit. This brings the difference between the pre-war profit of 11½d. and the latest figures from 2s. 7d. up to 3s. 1d. Clearly the presence of an excess profit of 3s. 1d. a ton must be taken into account in any budget as to the cost of the miner's claims.

(iv.) In the same period in which total profits were trebled, wages only doubled. Profits rose by 200 per cent., wages per person from £82 in 1913 to £169 (in each case subject to the reduction of a small sum for employer's deductions) or 106 per cent.

(v.) The total capital of the mining industry was estimated by Dr. J. C. Stamp [Q. 771] at £135,000,000. On the pre-war output of 270 million tons this works out at about 10s. per ton, while the pre-war profit (less royalties) of £13,000,000 is between 9 and 10 per cent., or nearly 1s. a ton (1s. 6d. a ton if royalties are included).

The following table gives the detailed figures explaining the graph on the page opposite. It will be seen that the pre-war standard of profit, prices, and wages is taken as the base line of 100. It should be noted that the initial figures of miners' incomes represent, not the five years' average, but the year 1913:—

AVERAGE 1909-1913.	1914		1915.		1916.		1917.		1918. Jan to June (on annual basis).		1918 July to Sept. (on annual basis)	
	Amnt.	Per cent.	Amnt.	Per cent.	Amnt.	Per cent.	Amnt.	Per cent.	Amnt.	Per cent.	Amnt.	Per cent.
Profits per ton (excluding royalties), 11½d. = 100.	1/1½	117	1/8	174	2/11	304	2/2	230	1/8½	178	3/6½	369
Pithead prices per ton., 8/9 = 100.	9/11½	114	12/5½	142½	15/7½	178	16/8½	191	20/-	228	24/10	283
Yearly wages (1913) £82 = 100.	£79	96½	£105	128	£127	154	£129	157	£149	181	£169	206

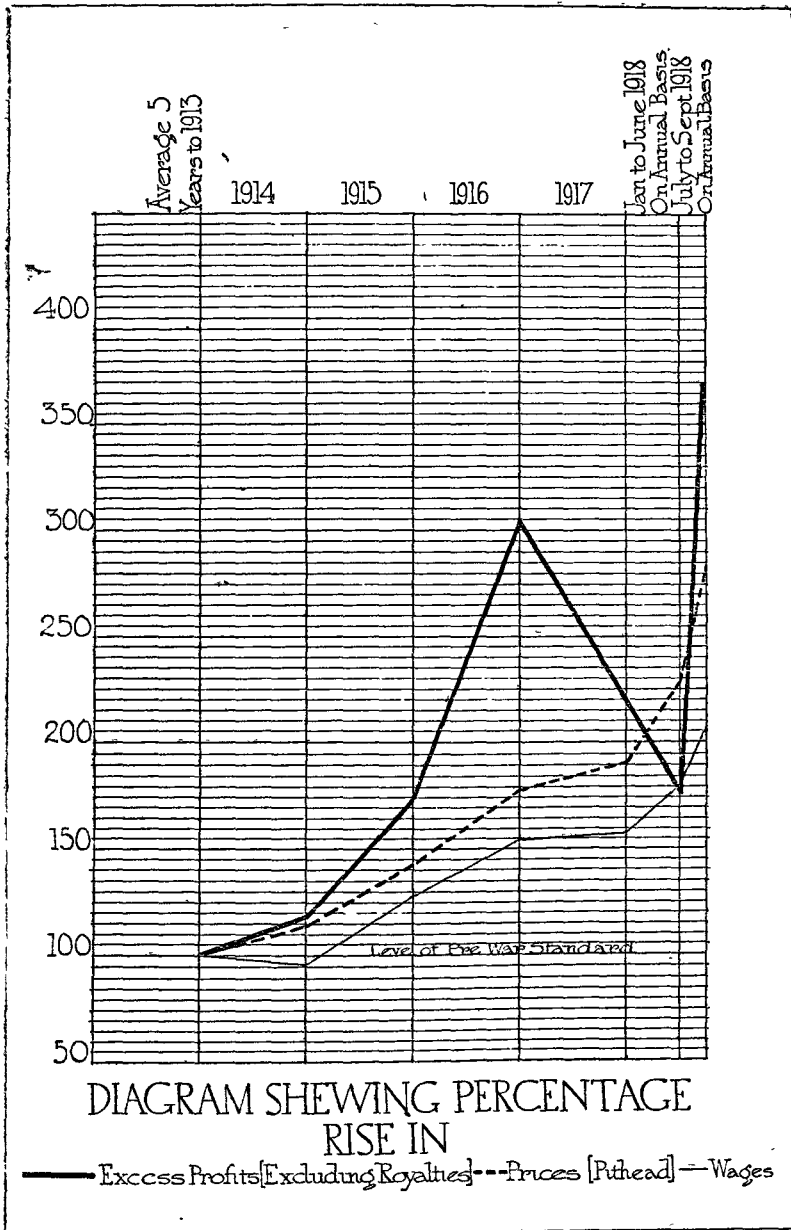
THE EXCESS PROFITS.

The Excess Profits Tax took a certain percentage of profits over and above the pre-war standard of profits. This percentage was—

50 per cent	in the Finance Act of 1915.
60	" " " " " " 1916.
80	" " " " " " 1917.

Thus, until the last 18 months of the war, the coalowners were able to retain an enormous portion of the excess profits.

Further, in fixing the pre-war standard of profits for each undertaking, one could take either two out of three pre-war years, or four out of six, while, unlike the Income Tax assessment, royalties and interest were treated as



deductions, and beyond that there was a special deduction of £200. It is obvious that the Excess Profits Tax was by no means harsh to the colliery proprietors.

Besides, under the Finance Acts it was open for any firm, if it could show by taking four years out of six, or in some other way, that its profits were not very high for those years, to claim instead that a statutory rate of interest should be substituted for the profits standard. In the case of coal mines *this statutory rate of interest was 9 per cent. on capital.*

"I think you will easily see that the effect of that selection must necessarily tell against the Government and in favour of the owners; that is to say, in place of the Government giving standards for the aggregate of the whole industry of capital profits for a certain definite two years or a certain definite three years, they really in effect give a standard which is very considerably in excess of that amount." [Q. 53. Mr. Dickinson.]

From this it is clear that very great allowances were made, from which the nation suffered and the coalowners gained, before the swelling dividends even began to count as excess profits. After March, 1917, when the Coal Control was set up, 15 per cent. of the excess profits went to the Coal Controller, of which, with the Exchequer's 80 per cent., left 5 per cent. to the undertakings with profits in excess. This may seem comparatively little for the profiteers compared with the enormous proportion obtained in the earlier years of the war. But against any such notion may be offset the fact that all of the 15 per cent. to the Coal Controller, and more besides, was given back to help the collieries which were making less than their pre-war standard of profits (which may have been very high). *For pre-war profits had been guaranteed* by the Coal Control Agreement (the terms of which were excluded from public discussion in the Press by order of the Press Bureau). Thus the 15 per cent. and more went to make up profits, while the 5 per cent. went as a present entirely to coalowners who were already doing very well.

At the present moment various efforts are being made to have the Excess Profits Tax abolished, on the ground that it cripples industry. This argument hardly fits in with the extraordinarily generous provisions outlined above. But it is best met by a quotation from the evidence of the Deputy Director of Naval Contracts to the Admiralty [Q. 1818]. "I have never found that the Excess Profits Tax prevented any contractor asking for increased prices."

DISTRIBUTION OF PROFITS.

"LAW OF RENT."

How did it come about that of the 20 per cent. excess profit left when the Exchequer had taken 80 per cent., 15 per cent. was swallowed up (and more besides) by the collieries which were making less than pre-war profits, while 5 per cent. went to those already doing well? The reason is to be found in the fact that owing to the differences between collieries "it was perfectly clear that the price of coal that is a fortune for some collieries still spells bankruptcy for a large number of others." (Q. 103.) When Mr. Sidney Webb asked "Is not that because the collieries are in different ownership?" the answer was "Of course, it is." Thus there might be a pithead price of coal which represented a loss of 6s. to one colliery and to another a profit of 6s. This difference of 12s. a ton means that the consumer and the miner both suffer. The price to the consumer (when there is no control) tends to be that which will keep the least efficient colliery going (and incidentally give a huge margin of profit to the more efficient or better equipped collieries). Either that or, where the price is not high enough for some, the mines are shut down

and valuable coal is lost to the community. (Q. 650 *et. seq.*) Wages, too, depend on the ability of the worst mine to continue working. Again—

Price goes up 2s. 6d. in June, 1918.

A concrete example will be useful. In the beginning of 1918 the coalowners were asking for an increase in the price of coal. The Coal Control, on examining the statistics of the industry for the last two months of 1917 to see if this claim was justified, found that (out of 75 per cent. of total tonnage)—

the concerns producing 62 per cent. had a profit of 2s. 3d. a ton.
" " 13 " " loss " 2s. "

To meet these minor losses and maintain the pre-war standard of profit *which had been guaranteed* the Coal Control was paying out about £850,000 a month, which more than swallowed up the 15 per cent. allocated to it from the collieries paying excess profits. Partly because of a debate in Parliament over the Coal Control Agreement (Confirmation) Bill in February, 1919, in the course of which the Government gave a pledge that the Coal Control should be made self-supporting, and partly because a large number of collieries were anxious to be in a more favourable position should the Coal Control cease, it was decided in June, 1918, to add 2s. 6d. per ton to the price of coal. This meant that in order to save £850,000 a month, or about £10,000,000 a year, the Controller fixed on the consumers an additional cost of £25,000,000 per year.

Consumers Robbed to the Tune of Twenty-five Million Pounds.

It should be noted that this immense toll could not even have been demanded if the collieries had been under a unified system:—

"Sir L. Chiozza-Money. You had to be very tender to the colliery owners in the country?—Yes.

"And we all had to pay for that tenderness?—Yes.

"Mr. Sidney Webb: If there had been one great coal trust there would not be that

"If the profits had been pooled you could not put the price up.

"In short, if they belonged to the nation you would not put the price up?

"That is my opinion. I do not know that I ought to give opinions."

Further, even under private ownership, it would not have been granted had the Coal Control possessed the necessary information. This is made clear as follows:—

"Sir L. Chiozza Money: I cannot understand it. I go back to the statement you gave us and find the profit of 1s. 8½d. a ton without royalties, 2s. 4d. with royalties, and 2s. 10d. with the by-products. I cannot understand why, in view of these figures and the pre-war average you gave us, it was necessary to put 2s. 6d. a ton on coal.

"Mr. A. Lowes Dickinson: I must ask the Commission to remember we had not got these figures for more than a month or two. We had not got them, and it is only as a result of all the tabulations and returns we have got.

"Mr. Sidney Webb: We granted 2s. 6d. extra on coal without knowing what the cost was?—Without knowing all these figures.

"Would not the Coal Controller know these figures?—When the 2s. 6d. was granted in June we knew nothing about the quarter ending March. The last information we had was 2s. 6d. which was granted in June when we had the returns for November and December, which I have referred to.

"If you had known what you know now probably the Controller would not have recommended the 2s. 6d., in the face of the extraordinary profits?—That, again, is a matter of opinion.

"Sir L. Chiozza Money: You did not know, and therefore could not tell his Majesty's Government?—No.

"The War Cabinet did not know?—No.

"The Prime Minister did not know?—No. [Q. 203-9.]

CAPITALISATION OF RESERVES.

We have seen that the effect of the separate ownership of coal mines has been to increase still more the profits of those collieries (probably the vast majority) which were already doing well. It is interesting to cite from the evidence of Emil Davies the facts regarding a few of these concerns.

Mr. Davies says —

“The following are instances of colliery companies' profits, the extent of which has in most cases been obscured by the capitalisation of reserves or other readjustments of capital.

“It will be seen that the most successful companies are able by these methods and by dividends, which are in reality much larger than they appear, to return to their shareholders every few years the whole of the share capital originally subscribed by them; and that the undistributed reserves are still so considerable that the present market price of the shares is several times their nominal value.

“It is submitted that if the coal reserves of the country were pooled, the enormous profits made—and partially concealed—by the large companies would be available to meet part, at least, of any additional working costs that may be necessary; and the incentive to build up reserves for subsequent distribution, which obscures the enormous profits actually being made, would disappear.”

COLLIERY COMPANIES' PROFITS.

THE POWELL-DUFFRYN STEAM COAL COMPANY.

A company with an ordinary share capital in 1913 of £541,000 odd and £115,000 odd in preference shares disclosed profits, after deducting depreciation, Income Tax, Excess Profits Duty, and coal mines excess payments for the 15 years ending last year, of about five and a-quarter millions sterling, of which over three millions have been paid out in cash dividends, in addition to which £1,100,000 of bonus shares, which are now worth three times that amount, have been distributed as a free bonus. I have worked out that £1,000 invested in 1903 in those shares would have received dividends since that time equal to £3,800, and would, in addition, with the bonus shares received, now be saleable for about £5,500. The company has just recently offered another bonus to its shareholders by allowing them to take up new shares for 35s. at the rate of one for five, and the existing shares are quoted at 61s.

THE OCEAN COAL AND WILSON'S LIMITED.

This company was registered in 1908. In that year it had ordinary share capital of £2,000,000 and £1,396,000 in 5 per cent. cumulative preference shares. During the eight years ending 1917 they paid out over three and a-half million pounds in cash dividends and gave away one million pounds of bonus shares, which are now worth over three million pounds. £1,000 invested in 1913 in these ordinary shares, when they were quoted at £10 for the £5 share, would have received cash dividends equal to about £745 in the five years, and would be saleable now for £2,365.

THE LOCHGELLY IRON AND COAL COMPANY.

This is a much smaller company. Its capital is £140,000 in 5 per cent. preference shares and £210,000 in ordinary shares. For ten years ending May, 1918, the dividends paid on the ordinary shares were over £200,000, in addition to which a visible reserve of £150,000 and a carry forward of £18,000 odd have been built up out of undistributed profits, and as shown in the accounts. £1,000 invested in this company's shares in 1910 would have received dividends equal to about £287, and would now be saleable at a little over £2,000.

THE MANVERS MAIN (YORKSHIRE).

In 1915 shareholders in the Manvers Main were given one bonus share for every two shares held. For the ten years ending June, 1918, the dividends paid were equivalent to 163 per cent., but that is counting the bonus shares. On the actual capital, the dividends for the ten years are equal to 195 per cent. In addition, the company has paid off in the last ten years out of profits £285,000 odd of debentures. £1,000 invested in these shares eight years ago at their then price of £1 16s. 6d. each would have received in cash dividends £840, and could now be sold for about £2,500.

THE FIFE COAL COMPANY.

The Fife Coal Company is a very large concern. In 1909 the shareholders were given, for every four shares they held, one bonus share and one 5 per cent. preference share. During the ten years ending 1918 the dividends paid were equivalent to about 243 per cent. on the increased capital, including the bonus shares, or over 300 per cent. on the actual capital. In addition, the accounts brought out a fortnight ago show a reserve of £500,000 and a carry forward of £126,000. Now this company, it seems to me, has created a secret reserve, because it is writing down its assets, but it has called its shareholders together to give it powers to make distribution of bonus shares.

WHOLESALE AND RETAIL TRADE.

The Four Tiers of Middlemen.

Before the coal gets to the consumer, it has to pass through the hands of the middlemen, and not through one set of them, but through four tiers of middlemen, each rising behind the other, and each of them imposing a profitable charge. The result is that the working classes have usually to pay about twice as much as the price at the pit's mouth. The usefulness of these middlemen was seriously questioned by Mr. Smillie and other members of the Commission, who endeavoured to ascertain that if the whole of the coal supply were organised on a different basis a large number of useless middlemen would be eliminated, and the money thus gained applied in improving the service, cheapening the coal, and raising the income of the miner.

The Coal Control and the Status Quo.

When, however, the Coal Control took over the business of the wholesale and retail trade, it not only decided to continue the old method of distribution, but also it unquestionably accepted the pre-war standard of profit. [Q. 999.] They went entirely on grounds of continuity, keeping each of the tiers of middlemen, and apparently the question of asking the London County Council or the municipalities (themselves very large buyers) to undertake the work was never even considered. [Q. 1,320 *et. seq.*] Further, every dealer was registered, every household had to register with a dealer,* and so it became a closed trade. The effect was that the Government organised distribution so as to make the dealers into non-competitive agents, and yet allowed them profits based on their pre-war standard, obtained under the then chaotic conditions of distribution.

London's Coal Trade.

The example of London is instructive. Here, to quote the Majority Report,

"The mere establishment charges of the firms engaged in distributing coal in London alone amount in the aggregate to over £800,000, and their total net profits to over £500,000 per annum."

* As far as possible, householders were encouraged to register with their previous dealers. As many wished to register with their co-operative society, the amount needed by the co-operative stores was much larger than their pre-war requirements. This caused a good deal of difficulty, and much dissatisfaction in the Co-operative Movement.

How is it that this enormous sum is loaded on to the already high price of coal? The answer is found in the fact cited above, that the Coal Controller took over the prevailing system with all its imperfections on its head and its profiteering as well. Mr. Tawney pointed out that the existence of a coal ring in London together with the acceptance of the pre-war standards meant the handing over to distributors of a considerable share in monopoly profits. [Q. 1,230.]

The actual sum allowed to be charged by the dealers on each ton of coal after it had been brought to London, with the railway rate, wagon hire, and any factor's charge all paid, that is after it was lying in a London depot ready to be carried off, was no less than twelve shillings and sixpence (12s. 6d.). This singularly wide "margin," as it was called, of 12s. 6d., was taken by the 680 merchants and 1,600 coal dealers in the London area. It is no wonder that it could be stated at the Commission that "the men's demand in respect of wages, as far as London is concerned, comes to only a few pence more than the establishment charges of the retail agents, plus one more factor." [1,650.]

The London Coal Ring.

Mr. Lee, the secretary of the Coal Mines Department of the Board of Trade, appeared to ignore the existence of any ring or combine on a large scale in London, and naively stated that in fixing the profit margin the view had been that the "ordinary force of competition" would keep profits down to a reasonable level. Further light on these views, on the way in which the very high profit standard was fixed without reference either to the possibility of cheapening the service, or to the known fact that the Co-operative Wholesale could do it more economically than under the prevailing pre-war system, and on the existence of a combine, emerges from the following evidence:—

Mr. SIDNEY WEBB: Supposing, for instance, you have here a shilling for the delivery over the wholesale to the retail merchant. Have you inquired what the Co-operative Wholesale Society does that business for in supplying local societies who are in the position of retail merchants?

WITNESS: No.

Mr. SIDNEY WEBB: That would have been an obvious standard to have taken. Those figures are known. I am on the point of what inquiry you made before accepting these rates as reasonable. It would be known to anybody that the English Co-operative Society does a large business in coal in London. Before you fixed that price of 1s., it would be natural to inquire the Co-operative Society's figure, because that is a quasi-public institution, and doing the work for the bare cost?

WITNESS: What we did was to take a number of representative firms.

Mr. SIDNEY WEBB: That is to say, you consulted the firms themselves as to how much they would like to charge?

WITNESS: No, we examined the books to see what they had charged.

Mr. SIDNEY WEBB: Then you did not examine the Co-operative Society's books to see how much cheaper that might have been done?

WITNESS: No, because, in any case, our view was that the returns obtained by these firms in the pre-war period under the normal operations of competitive conditions gave a fair return for the work.

Mr. SIDNEY WEBB: It is many millions. [Q. 1,243-1,247.]

Mr. SIDNEY WEBB: When you say competition prevailed, I thought there was one of these firms which had several aliases, which did a very large percentage of the entire distribution in London. I have heard it put as high as three-fourths. Put it as high as five-eighths. You know the firm I am alluding to?

WITNESS: Yes.

Mr. SIDNEY WEBB: Had you that in mind?

WITNESS: Yes; they are in competition with other big concerns.

Mr. SIDNEY WEBB: You say other big concerns. You have one concern which does three-fourths of the trade.

WITNESS: I do not know that that is so. . . .

Mr. R. W. COOPER: Are you referring to William Cory and Sons?

Mr. SIDNEY WEBB: Yes. (To the witness): I have heard it put as high as three-fourths of the whole trade. You have one firm doing a large percentage of the trade, and then you say there is no evidence of combination. [Q. 1,254-9.]

The Example of the Co-operative Societies.

The following facts from the Wholesale Co-operative Societies, into whose methods the Coal Control did not think it worth while to inquire, show that after all expenses have been paid and a margin allowed that is really fair (not "fair" as interpreted by the Coal Controller after his inspection of coal merchants books) the member of a co-operative society gets his coal from 2s. 6d. to 5s. a ton cheaper than the non-co-operator. The co-operative societies were not allowed to sell the coal at a cheaper price than that fixed by the Controller. They were compelled to sell at the fixed price, which gave the ordinary merchant his high profits. But they cheapened it by giving it back to the consumer in dividends which ranged from 2s. 6d. to 5s. per ton in England and stood at about 3s. 9d. in Scotland. This cheapening was made possible both because the co-operative societies were more economical and because they charged less of a margin. The conclusion is brought out in the following excerpt from the evidence:—

Mr. SIDNEY WEBB: We may take it that the saving of 2s. 6d. in the low dividend up to 5s. in the highest dividend on each ton of coal to the consumer, if he is a co-operator, is a real saving in the cost of distribution?

C. W. S. WITNESS: Yes.

Mr. SIDNEY WEBB: And that saving is made because the co-operative system of distribution is more economical than the system of distribution by a number of merchants and dealers?

WITNESS: That is so. Q. [9267-8.]

Waste in Competitive Distribution.

It was revealed in the examination of Mr. E. H. Davies, who is in charge of the Supplies Section of the Coal Mines Department, that there had been very great waste in cross-distribution of coal. Thus coal was sent to the North of Scotland from South Wales and from Scotland again to South Wales. In the autumn of 1917 the Coal Control divided the country into 23 areas of coal production and coal consumption. It was then found that North Wales, for example, did not produce enough for its own consumption. Its total production of rail-borne coal for inland consumption was 150,000 tons a month; its total consumption 220,000 tons. Yet it exported 40,000 tons, and so had to import 110,000 tons, whereas 70,000 tons should have sufficed. This wastage was done away with by stopping all export of North Welsh coal and by confining the inland importations to the three nearest areas with a surplus, whereas previously its import had come from no less than ten areas. Similar action was taken with regard to other areas.

As a result, Mr. Davies computed that by this transport scheme 700,000,000 coal ton miles per annum were saved, and thus on net weight, and excluding tare of wagons and empties. If these were included it would double the saving in railway working.

This represents a saving of £3,200,000, or £60,000 a week. This is roughly equivalent to 3d. a ton, while if the cost of empties, etc., is taken into account, it would make a full saving of 6d. a ton.

Thus, while under private control of distribution men were literally carrying coals to Newcastle, the cost of this exploit to the community amounted to a sum (6d. a ton) which would have met half the cost of the Government's first offer to the miners.

It may be noted that when this transport scheme was first mooted it was said that it would be unworkable, and that gasworks and other business would be compelled to take unsuitable coal. As a matter of fact it was found that the necessary exceptions only came to 5 per cent.

It was discovered also that within each of these very large areas there was a very great deal of wastage by cross-distribution. Unfortunately owing to lack of staff and pressure of work the Coal Mines Department were unable to remedy this. But enough was discovered to show that there was very great room for economies in this direction also.

Pooling of Wagons.

One of the difficulties of transport in the United Kingdom, both in the past and more particularly during the War, has been the system of privately owned coal wagons. These have to be returned empty to the collieries to which they belong, and one of the witnesses (Mr. Frank Tatlow, one of the Railway Executive Committee) stated that **half the mobile life of a privately owned wagon is taken up in empty running.** When it is realised that the number of privately owned wagons (about 700,000) is nearly one-half of the total number running on our railways, and that each wagon has to be sorted out by complicated shunting operations, it can be seen how great a loss this represents. One witness (Mr. E. H. Davies) reckoned that owing to this system we are at present using 35 per cent. (over a third) more wagons than are necessary. [Q. 2,052.] It was found impossible to state a figure indicating what would be the approximate saving in money.

An attempt was made by the Railway Executive to get these wagons pooled, but in face of the strong opposition of the private owners, representing separate interests, it broke down. A very slight concession was made by them eventually, but it was officially stated that only an infinitesimal percentage of wagons were pooled. [Q. 2,099.]

Two quotations from the evidence will show in a graphic way the present complicated condition and the waste entailed.

Mr. Frank Tatlow's evidence:—

"To my mind, the principal saving would be in connection with the sorting and arranging of the wagons at the different marshalling sidings. Now, of course, whether the wagons are generally owned or privately owned, there is, and is bound to be, a certain amount of sorting required, but that sorting gets very much severer when, in addition to the sorting of wagons into districts, you have to sort them out practically into names. You can put it in this way: If you have a pack of cards and you want to give 13 cards each to four people, it is an easy matter to deal the first four right round and so on; but if you have to give four aces to one person and four kings to another, then the sorting of the pack of cards takes a considerable time. That is the sort of sorting which would be eliminated if there were no private names on the wagons."

13 Owners for 40 Wagons.

(From Mr. Edwin Harold Davies' evidence):—

Mr. ROBERT SMILLIE: Will you take it from me that in examining a train of 40 wagons going through a Scottish railway station slowly I have found 13 different owners' wagons in the 40. When those are put into the sidings for shunting, have you any idea how long it would take the engine and the brakesman to do the shunting of those 40 wagons and get them sorted out?

Mr. DAVIES: It would depend upon so many circumstances. It would depend upon whether they had a clear road, the sort of engine, and the state of the roads themselves, and the skill of the men doing the work.

If I told you in the 40 wagons there was not a single one owned by the railway company?

That makes it difficult.

They were owned by 13 different owners; and before they found their way to the collieries 24 hours afterwards they had to be shunted out to their own ends. Would you believe that the general manager of the Caledonian Railway stated at a time when the pits were thrown idle for want of trucks—largely through want of engines and men—that if the wagons were common-user wagons, he could keep the collieries going full time at a time when the nation required coal?

I did not know he said that, but I can quite understand it would be practicable.

You admit there was the greatest possible difficulty in carrying on the traffic, and collieries could not be kept going?

At certain times undoubtedly.

Were you aware the members of the Coal Organisation Committee and the heads of several of the railway companies met with the private owners of wagons to endeavour to get the pooling of the privately-owned wagons?

I could not say I know. I think I have heard they have, but I am not sure.

It is amazing that the minutes of these meetings are not in your possession, and that you, practically in charge of the transport work, have not the proceedings.

No, they would hardly affect what I am doing in the Coal Mines Department, would they? [Q. 2,073 to 2,083.]

The Cost in Human Life.

The multiplication of shunting operations entailed by this sorting out of private wagons means a multiplication of the risks of death or injury run by railwaymen. This fact seemed to be rather inadequately appreciated by some of the railway officials who appeared as witnesses. We have the following:—

Mr. ROBERT SMILLIE: Have you any statistics as to the proportion of railway accidents which take place in the course of shunting operations?

WITNESS: No, I have not. I have seen the figures, of course, when I was with the railways. I know that such things do happen, but I have not any figures.

Mr. SMILLIE: You know that such things as accidents in shunting do happen.

WITNESS: Yes.

Mr. SMILLIE: It is amazing to hear it put like that by a railway expert. Is it not well known that a very large proportion of railway accidents take place in shunting operations?

WITNESS: I could not say what the proportion is, but it is risky work. [Q. 2,075-7.]

The Board of Trade figures [Cd. 8,059] show that on an average of the ten years before the war *one out of every 15 shunters was injured and one out of every 425 shunters was killed each year*. The risk run by the shunter (and also by the brakesman who in the absence of automatic couplings has still to do the coupling of wagons) is out of all proportion heavier than that of any other class of men in this dangerous occupation.

CHAPTER III.

THE MINER'S STANDARD OF LIFE.

Accidents.

It is seldom that the public realises that coal is won for them at a steady cost in human lives.

The miner lives under a continual risk of death or injury. Anything that shortens his hours of labour lessens that risk.

Mr. John Robertson, chairman of the Scottish Union of Mineworkers, showed in his evidence that in the mines—

In 1913	there were	1,753	killed.
„ 1914	„	1,219	„
„ 1907-16	(average)	1,240	„

In 1913 there were no less than 176,868 miners injured and off work for more than seven days. In the last 20 years the number injured reaches a total of 3½ millions. This, however, only refers to accidents which disable a man for more than seven days. If all accidents are reckoned up, "the number would be doubled," and the total number injured in 20 years would mount up to 6½ millions. The following description of the risky nature of the miner's work was given in the evidence of Mr. Hartshorn:—

Then I would just say also that it is a very hazardous calling. I do not think the public fully realise that one out of every six or seven—certainly one in every seven—of all the men and boys employed in the industry, surface and underground, every year get injured to an extent that renders them idle for at least seven days, and a very considerable number of them, of course, are rendered idle for a much longer period, and large numbers of them are totally and permanently disabled. I think about four men are killed in the mining industry every 24 hours, Sundays and week-days. This is an occupation in which men are blown to pieces. Only recently I had to deal with a compensation claim for two young men, the only sons of parents, who were both killed instantaneously in one of the collieries in my district. That probably is not a thing that often happens, but it is by no means unique, and every miners' agent has that experience. When we get explosions, it is no uncommon thing to get four or five or six dead men laid out in the same house. I have seen a father, a son-in-law, and four sons—six of them—who all left the house hale and hearty in the morning, brought back in the evening charred corpses, and no one left in the home but the two widows, the mother and daughter. In the mining industry the casualties are more like those of the battlefield than anything else. The only difference between the soldier and the miner is that the miner can never ask for an armistice. He cannot even treat for terms of surrender. The casualties go on every day.

Inadequate Inspection.

Why is the death rate so high?

At the present time, it is true, the mines are inspected by the Government. But for many years there has been a demand for more inspectors and more efficient inspection. Besides this the Miners' Federation of Great Britain have been pressing for the appointment (by the workers) of inspectors from amongst the workmen whose salaries cost should be borne by the Exchequer. Mr. Frank Hodges put this point to a witness and, when the witness did not

appreciate the difference between appointment by the State and by the workers, asked :—

"But does it not seem to you to be much more to the point that the workman whose life is at stake should have the right to dismiss the man or appoint the man who is to look after his life."

Witness. "I cannot say."

The same witness (Mr. T. H. Mottram, Inspector of Mines for the Yorkshire and North Midland Division) stated that he had only a dozen men to inspect 461 coal mines, and that it was an impossibility for them to make an absolutely complete inspection of the mines in the division. When pressed by Mr. R. H. Tawney, the following evidence was given :—

Mr. R. H. TAWNEY: Do you think that if you had a larger staff, if you, as you said, had full responsibility for the safety of the men, you could improve the conditions of safety?—It would be utterly impossible for me to be responsible in the first instance for the safety of the individual.

Why?—Because I could never get there. There may be many cases in which I could never see the conditions for myself.

But if you had a larger staff, then they could get there more often, could they not?—That is true. If I have got to be personally responsible I should want a very big staff, I can tell you.

That is our point. That is to say, at the present time we economise money at the expense of the miner's life and limb?—I do not say that.

Housing.

The conditions under which the miner has to live, as given in evidence, were shown to be so abominable that one of the employers' side of the Commission said to the witness "After hearing the reading of your proof I am sure there is nobody here who would wish to ask you very many questions. The conditions that you refer to are such that they must certainly be put right."

The evidence dealt with housing in general, then with Northumberland and Durham as showing the overcrowding in mining areas, and finally with particular samples, as it were, of the conditions in Lanarkshire, in the middle ward of which half the houses are occupied by miners. Figures were also given showing how owing to the overcrowding tuberculous patients had to be herded together in the same bed with healthy people. A few excerpts from the evidence will be enough.

Overcrowding.

(Q. 8,837-8,860.)

Over the whole of England and Wales there are 3,139,472 persons living more than two in a room, equal to 9·1 per cent. of the total population. The total for the administrative county of Durham is 28·5 per cent. and in Northumberland 28·7 per cent. Both counties contain a large mining population, but owing to the presence in this total of residential middle-class districts the true enormities of overcrowding cannot be realised unless we take some of the mining districts by themselves. This can be put in tabular form as follows :—

Number of persons living more than two in a room :—

	Per cent
All England and Wales.....	9·1
County of Durham	28·5
County of Northumberland	28·7
Annfield Plain (Durham)	41·4
Leadgate (Durham)	43·6
Ashington (Northumberland)	32·2

Thus, even in England and Wales, where the housing conditions are acknowledged to be better than in Scotland, roughly one in every ten persons was living under conditions of overcrowding; but in certain mining villages of Durham this was true of four out of every ten persons.

Scottish Housing.

Housing conditions in the mining districts of Scotland are so bad that a special chapter was devoted to them in the report of the Royal Commission on Housing in Scotland (1917). If Lanarkshire (in the middle ward of which county nearly half the total number of houses are occupied by miners) is taken as a sample, we find in the town of Hamilton alone 27,000 out of the 38,000 inhabitants have to live in one and two-roomed houses. In Wishaw, another mining town,

2,768	persons	are	living	more	than	5	in	one	room.
1,237	"	"	"	"	"	6	"	"	"
510	"	"	"	"	"	7	"	"	"
190	"	"	"	"	"	8	"	"	"

Tuberculosis.

The terrible conditions of overcrowding are not fully realised until we consider the number of cases in which healthy persons had to share a room, and in many instances a bed, with tuberculous patients.

In Cambuslang and Blantyre parishes there were 218 cases of tuberculosis, of which 36 were miners. The sleeping accommodation was as follows:—

23	had	a	room	to	themselves.				
41	shared	a	room	with	1	other	person.		
38	"	"	"	"	2	other	persons.		
35	"	"	"	"	3	"	"		
20	"	"	"	"	4	"	"		
18	"	"	"	"	5	"	"		
18	"	"	"	"	6	"	"		
9	"	"	"	"	more	than	6	other	persons.

The following table of 278 tuberculosis cases in Bothwell and Cambusnethan parishes shows even worse conditions, as it refers to consumptives sleeping in the same bed with healthy people.

118	occupied	a	bed	alone.		
90	shared	a	bed	with	1	other.
59	"	"	"	"	2	others.
9	"	"	"	"	3	"
2	"	"	"	"	4	"

Pithead Baths.

One case was cited before the Commission of a pit in which the pit ponies died, while the men had to continue to work.

The miner returns to the upper air after nine hours or so spent in a semi-darkness in which he contract nystagmus (a disease of the eyes), and often in a foul atmosphere, his clothes covered with coal-dust, and himself often wet through with working in water or under the steady dripping from the roof. At present he has to wash and change in the room that also serves in many cases as the living room, bedroom, kitchen, washing house, and scullery. Often, too, he has to travel ten or twelve miles in his clothes, wet

to the waist. All these discomforts are additional to his ordinary housing conditions, with their disastrous social consequences.

Yet in France, Germany, and Belgium baths are provided at the pithead. In this country they exist in only two collieries. In the original draft of the Coal Mines Act of 1911 they were made compulsory. But before the Bill became law a provision was inserted to the effect that they must only be provided if a two-thirds majority of the miners voted in favour of it and *if the total cost did not exceed 3d. per head.* So far the collieries have not taken the trouble to present their accounts in such a way as to fulfil this provision.

Hours.

"Some apprehension," says the Majority Report, "has been caused by the phrase 'six-hour day.' It is not true that the miners already have an eight-hour day, secured to them by Act of Parliament. The statute of 1908, not as introduced by the Government and passed by the House of Commons, but as altered at the very end of the session by the House of Lords, made the eight hours date from the moment the *last* man of each shift entered the cage to descend the shaft, until the *first* man of the shift reached the surface. This excluded all the 'winding time,' which normally consumes on the average something like an hour, and in the most extreme cases officially reported to us by the inspectors takes as much as two and a-half hours per day. **The underground worker is thus actually below ground, exposed to a special risk of accident, not for eight, but, as we are informed officially, for between eight and a-half and ten and a-half hours per day.**"

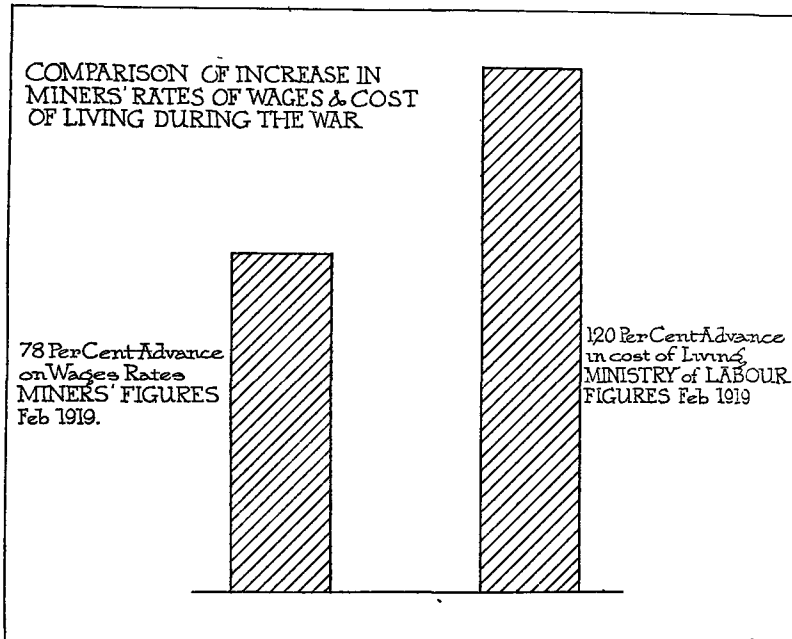
The most convenient summing up of the evidence given by Mr. John Potts, Treasurer of the Yorkshire Miners' Association, and by others, is again to be found in the Majority Report.

"We suggest, indeed, that the reduction of the hours during which each individual miner is exposed to his exceptional risk of accident is not only justified, but also a positive advantage to the nation. There are, at present, between 160,000 and 176,000 casualties in the mines each year—more in number than all those suffered by the whole Gallipoli Expeditionary Force—between 1,500 and 1,700 of them fatal, making the miner's calling more hazardous than any other except that of the seaman. In the ten years from 1907 to 1916 actually 12,400 miners were killed by accidents occurring in the course of their work. We cannot confidently predict that a lessening of hours will, in itself, result in a diminution of accidents, because there has unfortunately been no study of the extent to which the accidents in mines are effected by the men's fatigue. In other industries that have been investigated, it has been proved that a reduction of working time leads to a more than proportionate lessening of accidents. But, however this may be in mining, each individual miner will certainly be a shorter time at risk. The miner, as it has been graphically put to us, is during the whole of his working time continuously in the trenches. At present he goes on an average only six years before he meets with an accident, not necessarily fatal, but conspicuous enough to be reported, and severe enough to necessitate abstention from work for more than seven days. With a working day from bank to bank reduced by 28 per cent. it may be anticipated that the underground worker will go without an accident, on an average more nearly eight years than six. It must be counted, indeed, a distinct social advantage of a shorter working day in trades exposed to exceptional risk of accident, that it permits, on an average, to every worker (and therefore to every father of a family) a longer uncrippled life."

Wages.

The *précis* handed in by Mr. Vernon Hartshorn, M.P., read as follows :—

“ The advance of wages of 30 per cent. is not asked merely to meet the rise in the cost of living. It is asked for because of the resolve of the miners that their pre-war standard of life shall be raised. The opinion that an advance of 50 per cent. should be asked for was strongly entertained at the Southport Conference. The 30 per cent. represents the minimum that will satisfy the miners in their desire for a higher standard of life than that which they had in 1914.



“ The necessity of meeting the rise in the cost of living (which the Ministry of Labour now puts, February, 1919, at 120 per cent. above the level of July, 1914) enters into the demand. The total increase of wages since the beginning of the war averaged over all the districts of the Miners' Federation of Great Britain now stands at 78 per cent. This means that an advance of 42 per cent. on pre-war wages is necessary in order to restore the miners to the position of 1914.

“ But even supposing the miners' wages had risen further, or the cost of living had not risen so high, supposing the Government offer of 1s. (roughly equivalent to 10 per cent.) had restored the miners to their pre-war position, this would leave 20 per cent. as the miners' demand, which would be a very moderate rise when the whole conditions of the miner's life are taken into consideration. Further, if Mr. Lowes Dickinson's figures be taken, it would show that the profits of the coal industry had risen from a pre-war average of £13,000,000 to a rate of £39,000,000 for quarter ended September, 1918,

while the miner's average income had risen from £82 to £109 in the same period. This would mean that profits had been trebled, while wages had little more than doubled. **But the Federation figures show 78 per cent. advance during the war, and not 105 per cent."**

As I say there, even if such figures as I put in prove to be inaccurate, and even if the other side can prove that on the question of the standard of living, or the cost of living, wages have kept pace with the increase in the cost, yet the miners still say that the pre-war standard of living was so inadequate that they must insist upon a substantial advance in wages.

I think in considering this demand the general conditions of the miner's life and the nature of his employment must be taken into account. If you take the ordinary working day of any miner (I have in mind a representative case in my own district), the colliery starts winding coal at 7 o'clock in the morning. The men have to be down somewhere between 6 and 7 o'clock—say an average of half-past six. They come up between 3 and 4—say an average of half-past three. So that we get the miner in his pit clothes from about 5 in the morning until, say, half-past three when he ascends the pit, and by the time he gets home and has his food and a bath and gets out of his pit clothes again, it is half-past four. Of course, I think that a miner is at work all the time he is in his pit clothes. A man has to leave his bed in the cold winter mornings and come down into a cheerless kitchen without any fire. He cannot take his clothes up to his bedroom, but he has to come down to change, and the moment he gets his pit clothes on he cannot move from chair to chair or room to room. Every movement he makes leaves its mark, and it is the same when he comes home. You have had some evidence on the matter I have noticed during the day, and I do not want to detain you for any length of time on this position. Then, of course, you have to bear in mind that the collier's work is done in the bowels of the earth in the darkness. I think it is true to say that during the whole of the winter months a miner never gets more than one or two hours of daylight on any day except Sunday. I know from personal experience, having worked at the coal face myself for about twelve years, that it is a very arduous occupation and very laborious. I know when I was a growing lad it was quite a common thing for me, after I got home in the night and after getting my food, to lie down on the hearthstone in front of the fire, feeling too tired and stiff and lifeless to get a bath and rest. In the morning, when I was hauled out of bed, I felt it was like going to the gallows to get up at all. I think that is the common experience of the miner, having regard to the nature of his occupation.

CHAPTER IV.

THE MINER'S CLAIMS AND THEIR EFFECT.

The Miner's Claims.

The Commission investigated costs, profits, and prices, both in the coal mining industry (strictly so called), and also in the wholesale and retail trade; it also inquired into the miner's standard of life, his housing conditions, hours, risks, wages, and other circumstances. Further, it had to inquire into the effect of the following demands:—

1. 30 per cent. advance in wages (exclusive of war wage of 3s.).
2. Amendment of "Eight" Hours Act to "six" hours.
3. Nationalisation of mines and minerals (this, according to a Conference decision, to connote a measure of control by the mine workers).

It is best to take first of all the estimate of the increased cost furnished by Mr. A. Lowes Dickinson. The estimate was prepared on the assumption, amongst others, that the minimum reduction in output would be 10 per cent. It will be noticed, of course, that nationalisation is not an extra cost. It is, indeed, the only means, apart from a coal trust, of meeting the increased cost.

Estimate of the Cost.

Average output per person employed of five pre-war years...	257 tons.
Number of persons employed (say)	1,100,000.
Total output per annum	283 million tons.
Present cost without increase of wages or decrease of hours:—	
Wages, £194,000,000, equals per ton.....	13s. 9d.
Other costs	6s. 5d.
Total costs.....	20s. 2d.
30 per cent. increase in wages	£45,000,000
Reduced output owing to reduction in hours (say)	10 per cent.
Resulting output with same number of men.....	225 million tons.
Cost would be:—	
Wages, £239,000,000, equals per ton.....	18s. 9d.
Other costs per ton	6s. 9d.
	25s. 6d.
Increased cost due to both demands, per ton 5s. 4d. on	
255 million tons, equals	£68,000,000
Divisible as follows: Wages increase.....	£45,000,000
Reduced hours	£23,000,000
	£68,000,000

Estimated profits on present basis of hours and wages in excess of 1s. 6d. per ton: 3s 2d. per ton equals	£40,000,000
Deduct for fall in price of coal to neutrals, 1s. per ton	£12,000,000
	<hr/>
	£28,000,000
	<hr/>
Deficit to be made up...	£10,000,000

How to Meet the Cost.

Sir Leo Chiozza-Money's Suggestions.

It will be noticed that the table given above does not allow for any economies that might be introduced in production or distribution.

Some very interesting hypotheses was put by Mr. Leo Chiozza-Money as to how the deficit of 5s. 4d. a ton could be covered and more than covered by economies resulting from fall in costs, abolition of royalties, economies in distribution, etc., quite apart from the saving to be achieved by nationalisation and improved methods of production. These economies are stated in each as so many pence per ton!

Economies.	Saving of s. d.
(i.) Extinction of Royalties	0 6 per ton.
(ii.) Fall in cost of mining stores	1 6
(Timber, fodder, explosives, etc., all of them standing at exaggerated figures.)	
(iii.) Saving of railway costs	1 0
(Pooling of wagons, etc.)	
(iv.) Extinction of middleman, at least	3 0
(Most capable agents being retained and organised and the others paid out.)	
(v.) Excess profits	2 6
	<hr/>
	8 6
Deduct 1s. for decreased price of coal to neutrals	1 0
	<hr/>
On the hypotheses, total saving of.....	7 6

This 7s. 6d. a ton saved by these economies is so much more than the cost of 5s. 4d. a ton estimated by Mr. Dickinson that it leaves a wide margin to absorb any further cost due if the reduction in output were greater than the figure assumed—10 per cent. All this can be carried through, the miner's standard of life raised, his chances of safety increased, and an enormous amount of waste and extravagance done away with, if only financial unification of the mines is completed and distribution taken out of the hands of private traders without attempting any improvement in the methods of production.

How to Save Still More by Improved Methods.

Evidence of Sir Richard Redmayne.

Almost the weightiest evidence given before the Commission was that of Sir Richard Redmayne, H.M. Chief Inspector of Mines, Head of the Production Department of the Controller of Coal Mines, Technical Adviser to the Controller of Coal Mines, Chairman Imperial Mineral Resources Bureau; he was also a member of the Committee appointed to inquire into the probable economic effect of a limit of eight hours on the working of coal mines, Chairman of the Coal Mining Organisation Committee, and a member of the Coal Conservation Committee.

It is only possible to deal with a few of the points dealt with in his evidence.

Probable Effect of Reduction of Hours.

1. The reduction of time at the working face he estimated at 24·3 per cent., but as a reduction in output (for reasons which he gave) is not in arithmetical proportion to reduction in working time, he arrived at an estimated **immediate** reduction of output of not more than 19 per cent.

2. In this estimate no account is taken of numerous factors, each of which would result in increased output, and many of which could be brought into play within a very short period. Amongst these factors are the following:—

1. The making good of the loss of technical efficiency resulting from the abstraction of the most efficient miners for war service, and from the temporary worsening of the equipment of the mine through lack of supplies of timber, rails, sleepers, etc., caused by the war.

2. The possibility of reducing discontinuity of working by better "clearance" from the pithead, by the pooling of privately owned wagons, and by improved methods of stocking coal and filling from stock.

3. The reduction of voluntary absenteeism, as to which there is evidence that the shorter working day would cause considerable improvement.

4. The conveyance of underground workers to and from the face by mechanical haulage.

5. The utilisation to a greater extent than at present of the upcast shaft for winding coal and for raising and lowering miners.

6. The greater use of two-deck cages.

7. The improvement of winding plant and engines.

8. The extension of the multiple shift system.

9. The greater use of mechanical coal cutters, pneumatic drills, etc., as to which it may be remarked that at present only 10 per cent. of our coal output is got by machinery.

10. The fact that the shortening of working hours would increase (a) the health, and (b) the safety of the miner.

Collective Production.

Sir Richard Redmayne gave, as his considered opinion, that "the present system of individual ownership of collieries is *extravagant and wasteful*, whether viewed from the point of view of the coal mining industry as a whole or from the national point of view, is, I think, generally accepted." The

advantages which would result from a system of collective production he gave under the heads of—

(a) Enhanced Production.

(b) Diminished Cost of Production.

(c) Prevention of Waste, under this last including:—

1. Prevention of competition, leading to better selling prices for exported coal being secured.
2. Control of freights.
3. Economy of administration.
4. Provision of capital allowing of quicker and more extensive development of backward mines.
5. More advantageous purchase of materials.
6. Reduction of colliery consumption.
7. More harmonious relations between the workman and the operators due to steadier work and adequate remuneration of workmen.
8. Obliteration to a great extent of vested interests and middlemen.
9. Unification of the best knowledge and skill leading to greater interchange of ideas and comparison of methods. If good results are obtained at one mine and bad in another, these results would be open to all to benefit therefrom.

CHAPTER V.

NATIONAL OWNERSHIP AND JOINT CONTROL BY THE WORKERS.

Coal Trust or Public Ownership.

It is obvious that this "collective production" can only be carried out with its far-reaching economies and improvements by either a great Coal Trust or by Nationalisation.

Questioned on this point, Sir Richard Redmayne said that he was in favour of a Coal Trust, his reason being that he feared that the bureaucracy, which he considered to be bound up in national ownership, would be inefficient and deadening. Now, quite apart from the fact that the nation *simply would not stand* the idea of a Coal Trust—however much it was "controlled" by the Board of Trade—it may be pointed out that Mr. Straker (in his evidence on Nationalisation) proved the case for public ownership, as, indeed, it has been proved over and over again. The whole of the proceedings of the Commission—as reported in the Press—had the effect of one long continuous argument for Nationalisation.

Self-Government in Industry.

There is, however, a considerable ground for Sir Richard Redmayne's fears. The country's experience of the bureaucrats during the war has not been a happy one. But this fear was amply met by the last section of Mr. Straker's evidences, entitled

"Administration and the Avoidance of Bureaucracy."

Last year (in July, 1918) the Annual Conference of the Miners' Federation of Great Britain passed the following resolution:—

"That, in the opinion of this Conference, the time has arrived in the history of the coal-mining industry when it is clearly in the national interests to transfer the entire industry from private ownership and control to State ownership, with joint control and administration by the workmen and the State."

Accordingly, in order to give the Commission something "to bite on," as it were, Mr. Straker submitted a series of provisions for joint control, which are set out below.

As a first practical step to satisfy the larger demand and to place the administration of the industry, nationally and locally, on sound business lines, so that the interest of the miners and the community may be fully safeguarded, I beg to suggest the following provisions:—

1. There shall be established on the appointed day a Mining Council of ten members, five of whose members shall be appointed by the Minister for Mines, of which two shall especially be appointed to represent the interests of consumers, and five by the association known as the Miners' Federation of Great Britain.

2. The Minister for Mines shall be Chairman and an ex-officio member of the Mining Council.

3. Subject to the provisions of this Act, it shall be lawful for the Mining Council, on behalf of the Minister for Mines, to open and work coal mines and win and deal with minerals and generally to carry on the industry of coal mining, distributing, and vending, together with all other industries carried on in connection therewith. Provided that it shall not be lawful for the Minister for Mines or the Mining Council to lease any mine or minerals to any person, association or corporation.

4. The Minister for Mines may compulsorily purchase land or acquire such rights over land as he may require for the purpose of this Act, and shall have, with regard to the compulsory purchase of land, all the powers of purchasers acting under the Lands Clauses Act, 1843, and the Lands Clauses Consolidation (Scotland) Act, 1845.

5. For the purpose of this section the Mining Council, on behalf of the Minister for Mines, may from time to time, in such manner and on such terms as they think fit—

(a) Appoint managers, engineers, agents, clerks, workmen, servants, and other persons; and

(b) construct, erect or purchase, lease, or otherwise acquire, buildings, plant, machinery, railways, tramways, hulks, ships, and other fixed or movable appliances or works of any description, and sell or otherwise dispose of the same when no longer required; and

(c) sell, supply, and deliver coal and other products the result of coal mining operations, either within or without the realm; and

(d) enter into and enforce contracts and engagements; and

(e) generally do anything that the owner of a coal mine might lawfully do in the working of the mine, or that is authorised by regulations under this Act or by this Act; and

(f) employ agents, including local authorities or Trade Unions for any purpose they may think necessary to carry out their duties under this Act, on such terms as may be mutually agreed.

6. In addition to the powers conferred on the Mining Council on behalf of the Minister for Mines by the last preceding sub-section, the Council may, in such manner as they think fit, work any railway, tramway, hulk, ship, or other appliance for the purpose of winning, supplying, and delivering coal.

7. The members of the Mining Council shall be appointed for five years, but shall be eligible for reappointment.

8. The Minister for Mines shall, for the purpose of the carrying on and development of the mining industry, divide the United Kingdom into districts, and shall in each district constitute a District Mining Council of ten members, half of which shall be appointed by the Miners' Federation of Great Britain.

9. The Mining Council may delegate to any District Mining Council such of their powers under this Act as may conveniently be exercised locally, and the District Mining Council shall upon such delegation have and exercise within their district all the powers and duties of the Mining Council as may be delegated to them.

10. A District Mining Council shall, subject to the approval of the Mining Council, have power within their area to appoint Pit Committees for each mine or group of mines, composed of ten members, half of which shall be members of the Miners' Federation of Great Britain, and nominated by the workers of the mine or groups of mines aforesaid, and the District Mining Council may delegate to such Pit Council such of their powers concerning the immediate working or management of a particular mine or group of mines as the District Mining Council may, subject to the approval of the Mining Council, think fit.

11. The members of District Mining Councils shall be appointed for three years, but shall be eligible for reappointment, and the members of Pit Councils shall be appointed for one year, but shall be eligible for reappointment.

The Climax of the Commission.

These provisions for control very greatly interested, one might say excited, the employers' side of the Commission. Mr. Straker was subjected to a whole-day cross-examination (a prominence which was given to no other witness except Sir Richard Redmayne and Mr. Lowes Dickinson) entirely from the employers' side, and almost entirely devoted to this question of control by the workers. It was quite clear that the employers were more upset by the idea of workers' control than by the proposal merely to abolish private ownership. But the witness was rooted in certain definite principles which he had set forth and from which he would not yield.

This evidence came at the end of the second week, and was the climax of the Coal Commission. It was the open expression of the conflict between the opposing principles of autocracy in industry and industrial democracy. On that day it seemed as though the Miners were speaking not for themselves only, but for the cause of all their fellow workers:

It is fitting that this brief and necessarily imperfect summary of facts from the Coal Commission should conclude with a statement of principle. We quote Mr. Straker :—

“ Any administration of the mines under nationalisation must not leave the mine worker in the position of a mere wage-earner whose whole energies are directed by the will of another.

“ He must have a share in the management of the industry in which he is engaged, and understand all about the purpose and destination of the product he is producing ; he must know both the productive and the commercial side of the industry. He must feel that the industry is being run by him in order to produce coal for the use of the community, instead of profit for a few people. He would thus feel the responsibility which would rest upon him, as a citizen, and direct his energies for the common good.

“ This ideal cannot be reached all at once owing to the way in which private ownership has deliberately kept the worker in ignorance regarding the industry ; but as that knowledge, which has been denied him, grows, as it will do under nationalisation, he will take his rightful place as a man. Only then will Labour unrest, which is the present hope of the world, disappear.

“ The mere granting of the 30 per cent. and the shorter hours demanded, will not prevent unrest, neither will nationalisation with bureaucratic administration. Just as we are making political democracy world-wide, so must we have industrial democracy, in order that men may be free.”

APPENDIX.

Cross-examination of Mr. Benjamin Talbot,

By Mr. Robert Smillie.

8th March, 1919.

The witness appeared on behalf of the National Federation of Iron and Steel Manufacturers in order to show that the effect of granting the miners' applications for higher wages or shorter hours would cripple many industries. Cross-examined by Mr. Sidney Webb, he said that he should prefer a miners' strike rather than that the Government should concede their claim. Mr. Smillie followed later with a long and searching cross-examination of which what follows is a part:—

Are you really concerned about the future of the industry?—I am
And if the workers get a larger share of the wealth produced than they are getting now, it is likely to be very serious for industries?—Yes.

Mr. Forgie said that you were probably the best man that could be found to put the case of the iron and steel people of this country before this Commission. That was because of knowledge you possessed. Do you remember the total amount of wealth produced annually in this country prior to the war?—No, I do not.

Do you know how it was divided?—No.

Are you aware that of the total amount of the wealth produced only one-third came to the workers?—I take it from you.

Supposing that the workers secured two-thirds of the wealth produced in order to improve their standard of life would it be asking too much?—Not if it did not affect the economic position.

It will affect the economic position of some people undoubtedly; but would it be unfair to say that labour, which is the base and source of all wealth, ought to get two-thirds of the wealth produced by labour in return for producing it, in order that they may live decently?—No, I do not think it would be unfair.

I think you said that you are really concerned about improving the standard of life of the miners and other workers?—Yes.

Do you mean to improve it by keeping wages down to the lowest possible point?—No, I do not want to keep wages down. I want to increase the product and pay more wages by that.

You had 20 years in America, did you not?—Not 20; I was there about ten or twelve years.

Did you ever hear of scientific management when you were out there—that wonderful word "scientific" management?—I do not know whether they call it scientific. There was some very good management.

Did you imbibe a little of that?—Perhaps a little.

Scientific management means getting the largest possible output at the smallest possible cost, does it not?—Per ton.

Getting the largest possible output of anything at the smallest possible cost means the smallest possible wages to workers on which they can exist and go on working?—Oh no; they pay higher wages.

It requires 4 tons of coal to produce a ton of steel. Could you tell me what is the royalty rent on coal?—About 6d., is it not?

It is given at 6d. That is 2s. for the landlord. That is what the idle person gets out of royalties for every ton of steel that is produced?—Yes.

Have you any idea of asking that that burden may be taken off in order to enable the steel trade to go on?—Well, that is property, you know.

Oh, yes; property is sacred, but life is evidently not so sacred as property?—I have not said that.

I put it to you that the idle person who never was down in the mine to produce coal at all, and who has never seen a mine, is getting 2s. for every ton of steel that is produced. Is not that a burden on the steel industry?—Yes; as I say, it is their property; I do not know how you will confiscate.

Well, it is stolen property.—That is a matter of argument, of course.

There is no argument about it; it is a matter of fact, well known. What is the royalty rent on Cleveland iron ore?—About 4d. to 5d. a ton, I should think.

What is it on Cumberland ore?—That is very different.

Two shillings and sixpence, is it not?—There is a sliding scale.

But the average is 2s. 6d. a ton, is it not?—I daresay it is; I cannot remember. As a matter of fact it is?—I know it is high.

How many tons of Cumberland ore would it take to produce a ton of iron?—Say 2 tons to a ton of pig-iron.

For a ton of steel, how much Cleveland ore would it take?—Three and a-half tons of that ore for a ton of steel.

That is 8s. 9d.?—Yes.

How much lime does it take to produce a ton of steel?—Limestone; Cleveland ore, about 16cwt. or 18cwt.

Almost a ton?—Yes.

What is the royalty on that?—I should think about 1½d.

Or 1d. anyway?—Yes.

Are there any other raw materials on which there are royalty rents paid?—No, those are the chief.

Those are the chief, but are they all?—I think so. I do not know if there is any royalty on such things as ganister and silica.

I want to put it to you that there are royalties?—We use that in bricks.

We have already got 10s. 10d. a ton of dead charge on a ton of steel in royalties—not for going down to dig coal, mark you, but in royalties, 10s. 10d. a ton?—Yes.

And you come here and tell us that if the lives of the miners and their wives and little children are to be improved by better housing, better clothing, better education, better conditions, it is going to ruin the steel and iron trade of this country, while the owners, or at least the holders, of the soil of this country take 10s. 10d. per ton royalties out of that industry. Would it not be better now to release the industry from this 10s. 10d. and treat the miners fairly, rather than to come here and advocate that if the miners secured those things your trade will be ruined? Which of the two is the more humane—the abolition of royalty rents and the giving of decent conditions to the miners or to continue the present state of things?—You mean, of course, improving the miners' conditions.

At the top of your *précis* there is an amazing declaration that Mr. Benjamin Talbot will prove all those things: will prove that if the miner gets any part of his claim for an increase in wages or any reduction at all in his hours of labour, the steel and iron trade of this country will be ruined. Are you in a position to prove that?—Not any part; when you take extremes, of course not.

Now I do not say for a moment that the workers in the iron and steel trade are too well paid, but I do want to assert that it is unfair of you, an employer in the iron and steel trade, to come here and tell us that your own workers' wages have gone up 100 per cent. during the war, and their hours have been reduced by one-third during the war.—Just now, Mr. Smillie; it is just on now, remember.

And you say that while you have made those concessions to your workers, increased their wages to a higher degree than we have got for our workers, and made a reduction of one-third in their hours, you come here to oppose any change so far as the miners are concerned. Is it altogether fair? Are you happy in coming here to do that?—I am not happy at all.

Are you here under compulsion?—No, not under compulsion.

Do you know anything about the life of the miner, his home and his work, and things of that kind?—When I was a boy I have been down a pit.

You did not make up your mind to stay there?—No, I thought perhaps I should not get to the top.

Perhaps if it was only one visit, you were not in a position to form an opinion?—I used to go down often as a boy. I used to go down in doubles, and you know what that is.

And you would enjoy it, I am sure?—Yes, I did.

Do you know what the home life conditions of the miners are?—I knew it then, as a boy, in the miners' cottages.

You are representing a very large number of shareholders, directors, and people of that kind?—Not many directors, but perhaps twice or three times as many shareholders as workmen.

Do you know any of them who has an income of less than £500 a year?—Of course, I cannot tell.

You can tell—that not one of your directors in connection with this Federation has an income of less than £500 a year. Are there many of them have an income of £20,000 a year?—That I do not know.

Do you know anything at all about those people that you are connected with?—I do not know their private affairs.

You evidently do know the miners' private affairs, because you are here to oppose their getting an increase in a miserable wage that does not keep them in comfort; you are here to oppose that; and you are sent here by persons enjoying incomes from £10,000 to £100,000 a year for fear it will injure their income if the miners get fair-play. Well, I would be ashamed to come to endeavour to prevent such a class as miners receiving fair treatment. That is what you are here to do. Do you remember any large colliery explosions that have taken place in this country?—Yes, I remember some.

Do you remember the wonderful wave of sympathy that has gone over the country every time that 100 or 200 or 400 of our mining people were sent into eternity?—Yes.

Do you remember that for about seven or eight or ten days the newspapers were full of sympathetic letters saying the nation cannot pay those people too well for the work that they are doing, and do you remember also that shortly after the funeral, and when the inquiry is finished, you hear no more about the sympathy? Now that sympathy was well founded, I put to you. Do you think it was well founded?—Yes, everybody admires the miner.

Do you think it is fair to keep practically in starvation, and housed worse than swine in many cases, people that you admire?—Well, I hope it is not starvation.

It has been?—In the past, yes.

It has been at a time when we were establishing the steel and iron industry in this country. It was established with tears and starvation of the mine workers of this country, and I know it; I was one of them at the time?—I am sorry.

Now if you can manage to prove to this Commission that the miners ought not to get fair play, then you will have your choice which you prefer—a general stoppage of the mine working of this country; if you manage to prove to this Commission that because of the danger to the iron and steel trade and other industries the miners' position ought not to be improved, there is a serious danger of your getting satisfaction so far as your desire is concerned on the other side, I regret to say.

P 10

FURTHER FACTS

FROM THE

Coal Commission

BEING
A HISTORY OF THE SECOND STAGE
OF THE COAL INDUSTRY COMMISSION,
WITH EXCERPTS FROM THE EVIDENCE

COMPILED BY
R. PAGE ARNOT
(SECRETARY, LABOUR RESEARCH DEPARTMENT)

FOR THE
MINERS' FEDERATION OF GREAT BRITAIN

WITH A PREFACE BY
ROBERT SMILLIE & FRANK HODGES

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FURTHER FACTS

FROM THE

Coal Commission

BEING

A HISTORY OF THE SECOND STAGE
OF THE COAL INDUSTRY COMMISSION,
WITH EXCERPTS FROM THE EVIDENCE

COMPILED BY

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FOR THE

MINERS' FEDERATION OF GREAT BRITAIN

WITH A PREFACE BY

ROBERT SMILLIE & FRANK HODGES

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NOTE.

THIS pamphlet, after a statement of the issues before the second stage of the Coal Commission—to wit, the choosing of an alternative to the present system of ownership, already condemned in the interim report of Mr. Justice Sankey—analyses briefly the contents of the Reports, and reviews the order of events from the 20th July, when the Reports were published, to the 18th August, when the Government policy was announced. Then follow excerpts from certain parts of the evidence which appear to have weighed with the Chairman in his decision to recommend nationalisation.

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PREFACE.

The success of the publication, "Facts from the Coal Commission," was so pronounced as to suggest the idea that a similar booklet dealing with the work and findings of the Coal Industry Commission in its second stage would be equally well appreciated by the reading public generally and by the miners in particular.

In relation to the nation, the findings of the Coal Commission upon the evidence submitted to it during the second stage of its proceedings are far more important than the findings of the first stage as expressed in the Interim Report.

Then it was a question of advances in wages and a reduction in hours; now it is the question of the organisation and future government of the entire industry.

The generalisation of the Interim Report signed by Mr. Justice Sankey and three of his colleagues, "Even upon the evidence already given the present system of ownership and working in the coal industry stands condemned," has now given place to concrete proposals for effecting the change from private ownership and capitalistic working to national ownership and joint working between the State and those actually engaged in the work of production either by brain or hand.

The majority of the Commissioners recommend such a change. It is fundamental. It is a break with the past. It is a challenge to capitalistic tradition, the tradition that efficient production is alone compatible with the motive of profit making.

The facts speak for themselves. Efficient production has reached its high-water mark under private ownership, and under the same system decadence has set in.

Competition, absence of unification, uneconomical working, waste, endless discord, and strife between employers and employed, have made the coal industry a burden to the community. Instead of an industry self-supporting, and producing enough for all requirements abroad, giving good and cheap coal to the people at home, and providing the maximum social and material comfort to the men engaged in the work of coal production, we witness the industry gradually becoming a burden upon the community, a clog in the wheels of industry, and a source of unending conflict and national disturbance.

Fiercely, we think foolishly and heedlessly, the supporters of the old regime have embarked upon a great scheme of propaganda which is to prove that capitalism in the mining industry can yet make good.

Every capitalist avenue, political and industrial, is being explored and exploited to this end.

These attempts can be most effectually counteracted by a clear understanding of the whole of the facts of the industry, past and present.

A careful study of this booklet will help towards such an understanding, and we heartily recommend such a study of its pages to all who have an interest in the social and material well-being of the people.

(Signed)

ROBERT SMILLIE.

FRANK HODGES.

CHAPTER I.

Second Stage

OF

THE COAL INDUSTRY COMMISSION.

The first stage of the Coal Commission ended with the publication of the three Reports on March 20th, the adoption on the same day of the Sankey Report "in spirit and in letter" by the Government, and its acceptance by the miners' ballot* three weeks later.

Of this interim report, paragraph IX. .an as follows:—

"Even upon the evidence already given, the present system of ownership and working in the coal industry stands condemned, and some other system must be substituted for it, either nationalisation or a method of unification by national purchase and/or by joint control."

This paragraph showed that the Chairman and business men who signed his first Report regarded the second stage of the inquiry as being concerned in the main with the discovery of some alternative to the present system. This is made clear beyond dispute by the paragraphs subsequent to paragraph IX., which I quote in full below because at times it appeared from utterances of witnesses and from Press comments that the determining nature of paragraph IX. had been imperfectly understood:—

X.—To some of our colleagues whose opinion we greatly value, nationalisation has been the study or ambition of a lifetime, and they are prepared at once to report in its favour.

XI.—We understand that to others, whose opinion we greatly value, some scheme of joint control appear to be a solution of the problem.

XII.—No detailed scheme for nationalisation has as yet been submitted to the Commissioners; nor has any scheme for joint control been placed before them.

XIII.—No sufficient evidence has as yet been tendered, and no sufficient criticism has as yet been made, to show whether nationalisation or a method of unification by national purchase and/or by joint control is best in the interests of the country and its export trade, the workers, and the owners.

XIV.—We are not prepared to report now one way or the other upon evidence which is at present insufficient and after a time which is wholly inadequate, nor are we prepared to give now a momentous decision upon a point which affects every citizen in this country; nor, as appears from the report in Hansard above referred to, did our Chairman ever pledge himself to do so.

XV.—We are prepared, however, to report now that it is in the interests of the country that the colliery worker shall in the future have an effective voice in the direction of the mine. For a generation the colliery worker has been educated socially and technically. The result is a great national asset. Why not use it?

*The figures of this ballot (April 16th) were:—

For acceptance of Sankey Report	698,064
Against	76,992
Majority for ...	616,092

At the same time it should be emphasized that, as far as the proceedings of the Commission were concerned, the issue was in no way prejudged. During the second stage of the inquiry a comprehensive investigation was made into the merits of the policy of nationalisation. It is the more significant, therefore, that the Chairman should have regarded the conclusion of the first stage as more than confirmed by the second.

Changes in Personnel.

In the interval between the two stages of the inquiry Sir Thomas Royden resigned owing to ill-health, and Sir Allan Smith (Chairman of the Engineering Employers' Federation) was appointed a Commissioner in his stead. A few days after the second stage had begun, Mr. J. T. Forgie was compelled to resign for reasons of health, and his place was taken by Sir Adam Nimmo (who had resigned his official post as adviser to the Coal Controller). These changes brought a considerable accession of strength to the owners' side of the Commission.

Proceedings.

The second stage began on Wednesday, April 23rd, and lasted for nearly two months. Evidence was taken on 28 days of this period and 116 witnesses were examined. Of these the expert economists were taken first, then royalty owners (including peers and representatives of boring companies), Home Office witnesses, witnesses as to the working of nationalisation abroad or in the Colonies, technicians, coal owners, miners, miners' wives, industrial consumers, managers, expert administrators, and sundry other witnesses who escape classification. In addition, in accordance with the precedent set by several previous Commissions, notably the Poor Law Commission of 1906-9, and the Commission on Ecclesiastical Discipline, 1904-6, two members of the Commission, Mr. Sidney Webb and Sir Leo Chiozza Money, went into the witness box and submitted plans for systems of ownership and management in substitution for the present system. In view of the statement repeatedly made in the Press with a view to discrediting the Report of Mr. Justice Sankey, that insufficient attention was given to the interests of the consumers, it should be emphasized that numerous witnesses primarily interested in the consumption of coal were heard by the Commission.

There was perhaps no evidence submitted of so startling a kind as that given before the first stage of the inquiry. But a considerable consternation was caused by Mr. Smillie, who asked that various members of the nobility and royalty owners should be summoned before the Commission. This had perhaps a lesser effect on the Commission than it exerted in the country, where Mr. Smillie was much applauded by one section of public opinion, while on the other hand the Duke of Northumberland who had vigorously answered his cross-examiners, became a hero in the columns of the "Morning Post."

Miners' Witnesses.

The evidence for the Miners' Federation of Great Britain was presented on the 23rd, 27th, 28th, and 30th May. Mr. Henry H. Slessor, Standing Counsel to the Miners' Federation, submitted a draft Parliamentary Bill, embodying the miners' scheme for the nationalisation of mines and minerals. This was supported by Mr. Straker and Mr. Winstone, of the M.F.G.B., while evidence on the conditions of the miners' life was given by Mrs. Hart Mrs. Andrews. and Mrs. Brown, miners' wives, from Lancashire, South Wales. and Scotland respectively.

All Things Considered.

On one of the last days of the public sessions the Chairman, after analysing the classes of witnesses who had been called, stated that within the two months allotted to the second stage of the inquiry they had been able to hear almost every party or group of parties concerned in this country. Again, various vague charges were made that the Commissioners themselves were not representative of the consumers, but these charges were not sustained under cross-examination.

THE REPORTS.

Ready by 20th June.

At the beginning of the second stage the Chairman stated that he had promised Mr. Bonar Law that the second report would be ready in two months, and that May 20th was the date originally fixed. The sittings, however, had not recommenced until April 23rd, and accordingly, by the unanimous resolution of the Commissioners, the Report would be presented not later than June 20th.

This engagement was punctually fulfilled. By June 20th four Reports were presented, one by the Chairman; one by Mr. Frank Hodges, Sir Leo Chiozza Money, Messrs. Robert Smillie, Herbert Smith, R. H. Tawney, and Sidney Webb; one by Messrs Arthur Balfour, R. W. Cooper, Sir Adam Nimmo, K.B.E., Sir Allan M. Smith, K.B.E., and Mr. Evan Williams; and one by Sir Arthur Duckham, K.C.B., M.I.C.E.

Royalties.

On one point all four Reports were agreed, namely, on recommending the State ownership of all seams of coal, and hence of all royalties. The Acquisition and Valuation of Land Committee (of which Mr. Leslie Scott, counsel for the royalty owners, was chairman) had, during the sittings of the Coal Commission, issued an interim report, in which at least 14 defects arising from the present system of ownership of the seams of coal were pointed out, and in which it was proposed to set up a new sanctioning authority vested with power to issue compulsory orders to remedy these defects as to when they are in different cases found to exist. This suggestion was not considered drastic enough by any of the four Reports, and it was dealt with by the Chairman as follows:—

I regard as preferable to this expensive piece-meal machinery that the seams of coal should be acquired by the State once and for all in one final settlement, together with all usual or necessary easements and rights incidental thereto, together with power to procure all such easements and rights in the future. If the State only acquires the seams from time to time it means many arbitrations, many intermediate settlements, enhanced delay, and increased cost of administration.

Further, all the Reports agreed in recommending, in view of the overwhelming evidence of the extreme wastefulness of the system by which coal is at present distributed to the household consumer, that the machinery of Local Authorities and of the Co-operative Movement should be utilised for the purpose of distribution.

No Compensation for Royalties.

On the question of royalties, a special reservation was made by Frank Hodges, Robert Smillie, and Herbert Smith, who

- “do not agree that any compensation whatever should be paid to the present mineral owners for the mineral rights to be acquired by the State.”

This, however, was not to be taken to imply that there would be objection to the grant of compassionate allowances in cases in which small royalty owners are expropriated in such a way as to deprive them of their means of livelihood.

The Chairman's Report.

This Report recommended that the principle of State ownership of the coal mines be accepted. It further recommended that some scheme for local administration be immediately set up with the aid of the Coal Controller's department, and legislation passed to acquire the coal mines for the State, after the scheme had been worked three years from the date of the Report (during which time coal control would be continued), fair and just compensation being paid to the owners.

Reasons were then given for the State ownership of coal mines, amongst which perhaps the most significant were paragraphs xxiii., xxix., to xxxi. They occur after a reference to the defects of the present system and the necessity for collective production, and are as follows:—

XXIII. The other industries and consumers generally are entitled to have a voice in deciding the amount of coal to be produced and the price at which it is to be sold, which they have not had in the past.

XXIX.—It may be argued that the foregoing defects in the present system could be removed by changes in the direction of unification falling short of State ownership.

XXX.—But a great change in outlook has come over the workers in the coalfields, and it is becoming increasingly difficult to carry on the industry on the old accustomed lines. The relationship between the masters and workers in most of the coalfields in the United Kingdom is, unfortunately, of such a character that it seems impossible to better it under the present system of ownership. Many of the workers think they are working for the capitalist, and a strike becomes a contest between labour and capital. This is much less likely to apply with the State as owner, and there is fair reason to expect that the relationship between Labour and the community will be an improvement upon the relationship between labour and capital in the coalfields.

XXXI.—Half-a-century of education has produced in the workers in the coalfields far more than a desire for the material advantages of higher wages and shorter hours. They have now, in many cases and to an ever-increasing extent, a higher ambition of taking their due share and interest in the direction of the industry to the success of which they, too, are contributing.

Scheme for Local Administration.

After dealing with the method of purchase and carrying on of the coal mines, the Chairman's Report proceeds to outline a scheme of administration, which the time at his disposal allowed him to put forward only as suggestions for the use of Parliament, not as recommendations. It suggests Local Mining Councils, advisory bodies composed of ten members (three managerial, four appointed by the workers, and three by the District Councils).

In order to avoid bureaucracy, the Chairman adopts the machinery of District Councils (as proposed by the Miners' Federation), out of whose membership of 14 four are to be appointed by the workers. These District Councils elect a National Mining Council whose standing committee is advisory to the Minister of Mines, who is to be the supreme authority.

Report by the Six Members.

The Report signed by Hodges, Money, Smillie, Smith, Tawney, and Webb was in substantial agreement with that of the Chairman, and it was thought unnecessary to set out any separate statement of their views. In assenting generally to the Chairman's Report, several points were emphasised.

1. We suggest that, with a view to securing the cordial co-operation of the workers in the success of the industry, it is necessary to provide for a fuller representation of the workers on the District and National Councils, on the lines indicated in the scheme submitted by Mr. W. Straker.

2. Whilst fully recognising the necessity of working rules, and the importance of preventing unnecessary stoppages, we feel that the provisions of paragraphs L,* LXIV., LXXII., may be used to impose upon the workers by law a particular form of contract without their consent—an innovation to which we think it will be difficult to obtain agreement, and which we believe to be not the best calculated to attain the object.

3. We are of opinion that all coke and by-product plant attached to collieries should be treated as part of the coal mines, and should be acquired by the State with the coal mines.

4. We think it important that whatever payment is made to the owners pending the general acquisition of the mines should not be computed upon the tonnage gotten.

5. Whilst recognising, with regret, that the output from the mines has not yet satisfactorily recovered from the adverse circumstances which have depressed it during the war, we wish to emphasise the fact that no evidence has been produced to show that the men are refraining from doing their best. We believe that this is not the case, and that other causes are at work. The miners demand an immediate inquiry, and we support this demand. During the period that must necessarily elapse before the institution of the machinery for the administration of the mines proposed by the Chairman, we think that it is of the utmost public importance that there should be no deficiency of tubs, no lack of wagons, no shortage of materials, and no obstacle to prompt clearance from pit-head, all of which are reported now to exist.

The scheme submitted by Mr. Straker is compared in detail with that of the Chairman in a later part of this pamphlet.

The Coal Owners' Report.

This report is summed up in the sentence:—

“ We have carefully weighed the whole of the evidence, and have come to the conclusion that the nationalisation of the coal industry in any form would be detrimental to the development of the industry and to the economic life of the country.”

Not only is this Report against nationalisation, but it does not appear to be in favour of any substantial change in the present system of private ownership, merely recommending certain slight modifications along the lines of the Whitley Reports.

Sir Arthur Duckham's Report.

This report pronounced against nationalisation, but submitted instead a scheme of district unification, by which it is suggested that the present system of private ownership would be abolished and a system of publicly

* Paragraph L. in the Chairman's report ran as follows —

“ The contracts of employment of workmen shall embody an undertaking to be framed by the District Mining Council to the effect that no workman will, in consequence of any dispute, join in giving any notice to determine his contract, nor will he combine to cease work, unless and until the question in dispute has been before the Local Mining Council and the District Mining Council, and those Councils have failed to settle the dispute.”

Paragraphs LXIV. and LXXII. are repetitions of this proviso, applying it to district and national disputes.

controlled corporations, with guaranteed minimum rates of interest, would take its place. They would have a minimum rate of interest guaranteed by the Government, and of all profits above a certain maximum two-thirds were to be applied to reduce the price of coal.

Majority for Nationalisation.

Thus all four reports were agreed on the abolition of royalties and the State ownership of the coal seams. All were agreed as to the desirability of the distribution of coal being in the hands of public bodies. Secondly, eight of the 13 Commissioners propounded schemes in place of the present system of private ownership, already condemned in the first Sankey Report which had been accepted by the Government. Of the five Commissioners who refused to follow the accepted policy of the first report, two had not signed it in the first instance, two had been appointed later, while the fifth, Mr. Arthur Balfour, gave no explanation of his change of view. Thirdly, of the eight Commissioners whose reports were based on the policy accepted by the Government, all but Sir Arthur Duckham were in substantial agreement as to nationalisation of the mines as the best method of unification.

CHAPTER II.

THE GOVERNMENT'S POLICY.

From 20th July onwards.

It appears clear that the Government, who received these reports on the 20th June, were bound by their previous adoption of the first Sankey Report, "in letter and in spirit," to rule out any report which did not accept this principle of "nationalisation or a method of unification by national purchase and/or by joint control." As far as constitutional theory goes they are not bound to accept the reports of Royal Commissions. But in this case it was certain that the refusal to accept either the Chairman's report or the report of the six members would be regarded as a breach of faith. Further, the fact that seven of the Commissioners, including the Chairman, were agreed on nationalisation made a strong presumption in favour of the adoption of that principle; so strong, indeed, that, in the absence of any political obstacles, its adoption was assured.

The Power Behind the Premier.

Apparently, however, political obstacles were not absent. Before the end of June a formidable number of members of the House of Commons had sent in a cartel to the Premier, in which they strongly deprecated any acceptance of the principle of nationalisation, and announced that they would fight against it. The signatures to this manifesto were, presumably, not collected without a certain amount of canvassing. There is, indeed, considerable evidence that during the second stage of the coal inquiry a strong campaign was being engineered by various coal-owning interests (the Chambers of Commerce with one accord began to send in anti-nationalisation resolutions to Sir John Sankey), and that this campaign, both publicly and behind the scenes, was intensified from the middle of June onwards. Meetings were held, addressed by Lord Inchcape, Lord Leverhulme and other captains of industry. The Government received unmistakable warning of the deep hostility of the greater capitalists to any scheme of public ownership. Thus menaced, the Government adopted a waiting policy—or, as Mr. Bonar Law phrased it in reply to Parliamentary question, the "matter remained under consideration."

Meantime the miners' organisations and the other Trade Unionists of the country (who had time and again in the Trades Union Congress declared for nationalisation) undertook no counter-agitation, but awaited the decision of the Government. The only action they took was to make nationalisation of coal mines an issue in the bye-elections then pending at Swansea and Bothwell.*

* The results of these bye-elections went to show a very large transfer of votes from the Government candidate to the Labour candidate. In Swansea the Coalition just managed to retain the seat, in Bothwell Labour won. The figures are as follows:—

SWANSEA (EAST).			
DECEMBER, 1918.		JULY, 1919.	
T. J. Williams (Co. L.)	11,071	David Matthews (Co. L.)	9,276
D. Williams (Lab.)	6,341	David Williams (Lab.)	8,158
Coalition Lib. Majority	4,730	Coalition Lib. Majority	1,093
	Decrease in majority, 9,618.		
BOTHWELL.			
DECEMBER, 1918.		JULY, 1919.	
D. H. Macdonald (Co. U.)	9,859	John Robertson (Lab.)	18,135
J. Robertson (Lab.)	9,027	James Moffat (Co. L.)	6,367
Coalition U. Majority	832	Lab. Majority	7,168
	Difference between December and July majorities, 9,506.		

The 6s. Rise in Price.

On the 9th of July the President of the Board of Trade (Sir Auckland Geddes) abruptly announced that it would be necessary to increase the price of coal 6s. per ton.

This had the immediate effect of diverting attention from the reports of the second stage, of incensing the public against the miners, who were regarded (without warrant) as responsible for the projected increase, and, further, of turning public opinion, by an illogical but familiar process, against the proposal for nationalisation. It had an immediate effect on the Swansea electorate, which polled a day or two later (before any examination of the facts was possible) and recorded its vote against the nationalisation candidate.

The coincidence of this announcement with the climax of the bye-election in Swansea led many people to suggest that the announcement was a political move, a suspicion which was strengthened by subsequent happenings. We have, however, the assurance of Ministers that this was not so.*

Be that as it may, the necessity for the rise was immediately challenged by the Secretary of the Miners' Federation and by questions in Parliament. The Government agreed to issue a White Paper, giving the figures on which the decision to raise the price was based, and to allocate a day for a debate on the subject.

The Debate of 14th July.

When the White Paper was published it appeared that the Government had made a mistake in their previous estimate of 4th June. They had not allowed (in their reckoning of the output which would bear, by an increase in price, the two score million pounds and more put down as the deficit for the coming year) for the consumption in collieries, colliers' cottages, and bunker and export, on all of which the increase could not be placed. Thus the total increase assumed to be necessary to wipe out all the estimated deficit had to fall on a smaller total tonnage, and so to cause a higher price per ton.

The Government's calculations and revised calculations are made clearer by the following table:—

Estimated deficiency on the working of the coal industry for 12 months from 16th July, 1919		£
Estimated output for 12 months from 16th July, 1919.....		46,600,000
		Tons.
		217,000,000
Less quantity upon which an increased price would not be effective, viz. :—		
	Tons.	
Coal for colliery consumption.....	18,000,000	
Coal supplied for miners' use	6,000,000	
Coal for export and bunkers sold at open market prices above the minimum (on which it was assumed there would be no increased profit)	32,000,000	
		56,000,000
Quantity of coal over which the estimated deficiency of £46,000,000 is spread		161,000,000
		£46,000,000
Increase in price of coal =		161,000,000 tons
		= 5s. 9½d., say 6s.

* One of the strongest causes for suspicion of this kind was (to quote Mr. Brace in the 14th July Debate) that on "the very day that the right hon. gentleman (Sir Auckland Geddes) came down and made his dramatic announcement to the House there was a meeting of the Advisory Committee and the Coal Controller. There were present representatives of the Government, coal owners and workmen, but not a word was said there as to the necessity for placing 6s. per ton on the price of coal."

Quite apart from the Government's blunders in carrying out its calculations the whole basis of these calculations was seriously challenged by Mr. Vernon Hartshorn, Mr. Holmes, and other Members of Parliament.

Mr. Hartshorn showed that the Government figures, giving an estimated output of only 183 tons per miner, were based on the returns of 20 weeks, whereas the figures of 20 years showed that, even if allowance were made for a 10 per cent. reduction in output (consequent on the reduction of hours) the averages should be 237 tons per man.

This output would not merely do away with the rise in price of 6s. but would leave a surplus. "Instead of a deficit of £46,000,000 we would have a surplus of about £22,000,000."

Mr. Holmes, who spoke with authority as a chartered accountant of colliery companies, riddled the Government with calculations from another standpoint. He stated that the estimates had been exaggerated and that everything had been shown at its worst. He showed that during the war the customary underground repairs had been left over and for the purpose of meeting the cost of these repairs when the war was ended the coal-owners had been given allowances. Out of these funds which the colliery companies had accumulated under the scheme agreed upon with the Inland Revenue and the Coal Controller's Department should be paid the wages of some 60,000 workers during the next twelve months. They should not be charged against the year's profits. This alone would effect a reduction of 1s. a ton.

Secondly the profits of which the coal-owners were to retain 1s. 2d. per ton apparently did not include the profits from coke and by-products, which are estimated at £7,000,000.

EXPORT.

Again, the loss on export trade by its reduction from 34 millions to 23 million tons was put at £11,000,000, whereas it should stand at only £5,500,000. Moreover, the Government figures guessed that there would be no possible increase in the price of bunker coal and coal for export. This, of course, has already been falsified. To quote Mr. Holmes:—

"The more you reduce the amount you have to export the higher the price you will get for it. If we have only 23,000,000 tons instead of 34,000,000 tons to send abroad we shall get a higher price, because some people will have British coal, and as the supply will be less the demand will be more and the price will be greater accordingly. Under these circumstances, to put down 10s. per ton as the profit on the 23 million tons exported is perfectly ridiculous, **because this coal has gone up 7s. 6d. per ton in the past week** simply as the result of all this talk. I believe that, instead of 10s. per ton profit on export coal, we shall find in the ensuing 12 months, if you only export 23 million tons, that the profit will be nearer 30s. per ton.

Altogether Mr. Holmes showed that, even if the basic estimate of coal output were correct, there was no necessity to raise the price of coal by more than 2s. 6d. While, as we have seen, Mr. Hartshorn had shown that the basic estimate itself was wrong, in so far as it was calculated only on the figures of 20 weeks' output, whereas on his showing, if the figures of 20 years were taken there was bound to be a much larger output so far as the working miners were concerned. The Government were thus hit with both barrels.

The Fall in Output.

On the other hand, it was true that there had been for the previous few months a decided fall in output. Why then has there been this recent fall in output compared with what could be reasonably expected on the basis of 20 years figures?

The wording of the original announcement of the 6s. rise had left it to be inferred that the working miners were to blame. This was not sustained by Sir Auckland Geddes in his speech on the 14th of July in which he admitted that the fall in output was primarily due to transport difficulties. He instanced one group of 40 pits which used to have 10,000 wagons a week and which recently had only 700:

That bad organisation was the main cause was confirmed by Mr. W. Brace, who cited figures received from the South Wales collieries alone which showed the causes of out-of-work payments for last year as follows:—

- 157 collieries were unable to work for 670 days because there were no wagons.
- 113 collieries were idle because of insufficiency of trams and tubs.
- 101 collieries were idle because of a shortage of timber and rails.
- 111 collieries were idle because of a shortage of horses and mechanical power.
- 91 reported decreased output because of delay in repairs.
- 82 reported reduced output because of delay in developing work.

This evidence of defective organisation, which was partly due to war conditions, was consonant with much of the evidence given before the Coal Commission. It was pointed out by Mr. W. Adamson that the Chief Inspector of Mines had made a series of recommendations to guard against a loss in output arising from reduced hours of labour, and that no attempt had been made to carry their recommendations into effect. The responsibility, therefore, for the loss of output fell upon the shoulders of the Government.

Offer to Withdraw the Six Shillings.

At the close of this House of Commons debate (14th July) on the 6s increase, Mr. Bonar Law, on behalf of the Government, spoke as follows:—

“ All this is a question of what is best for the country, and I say, then, to my right hon. friends, that if they can give an equivalent for the dangers which I see in delay, if they can say to me on the floor of the House, ‘ If you postpone this for three months, we will join with you and put our backs into it to increase the output, and during that time there will be a period of suspense, and there will be no stoppages or strikes for the three months,’ I would be inclined to accept it, and I think the Government would do so also. I think that is a fair offer.”

The miners' delegates, however, to whom in their Conference at Keswick the “ fair offer ” was conveyed, considered that it was fair only on the surface, and that implicit in it was a charge that the miners were the parties responsible for the fall in output. This imputation they had repudiated, and indeed nothing resembling a proof of it had been adduced in the House of Commons debate, or elsewhere. Moreover, the three miners' representatives, together with the other three signatories, on the Coal Commission had asked for an inquiry into the fall in output several weeks previous to the panic. To this request, as well as to a similar request from the five Signatories of the coal owners' Report, the Government had paid no heed.

Consequently the miners refused to accept "a fair offer" whose acceptance would imply that they accepted the blame also. Instead, they passed a resolution in the following terms:—

This Annual Conference of the Miners' Federation of Great Britain having heard the report of the Miners' Members of Parliament upon the discussion in the House of Commons on the proposal of the Government to raise the price of coal by 6s. per ton declares that such increase is not necessary and should be avoided. It regards the problem as one of production only, and it is of the opinion that production can only be increased to a point which will make the industry self-supporting, without additional charges to the consumer, if the economies set forth in the Interim Sankey Report are effected, and the recommendations of the majority of the Commissioners as to an immediate change of ownership and control in the mining industry passed into law.

It, therefore, informs the Government that it is prepared to co-operate with them to the fullest extent to put such economies into effect and such recommendations into law.

No attention was paid to this proposal of the miners; instead, on the 21st July 6s. per ton was imposed by order of the Government. To sum up the whole episode:—

- (i.) The Government's estimate of June 4th was wrong.
- (ii.) The Government's estimate of July 14th as to output was wrong.
- (iii.) The Government's estimate of July 14th as to the loss on exports was wrong.
- (iv.) The Government's suggestion that the fall in output was mainly due to the miners was wrong.
- (v.) The Government's "offer" to withdraw the 6s. advance on an undertaking by the miners not to strike was irrelevant and only designed to place the miners in a false position with the public.
- (vi.) The Government's refusal to hold an inquiry into the cause of the fall of output was clear proof that it was less concerned with increasing output than with endeavouring to discredit the miners.

Redoubled Press Campaign.

It is to be observed that the newspapers, either through some misunderstanding or through some obliquity, completely failed to make it clear that the miners' responsibility for the fall in output was not proved, to say the least, and that the responsibility of bad organisation was proved. It is possible that the parrot cry for "more production" with its converse assumption that the working classes are given over to "ca'canny" had gradually had its effect. In the minds of newspaper writers an obsession now appears to be firmly lodged that the main cause of any fall in production is always the workers' "restriction of output." At any rate, whatever the cause, there is no doubt that the true position of affairs was seriously misrepresented—and none the less seriously when that misrepresentation was conveyed by the mere turn of a phrase or a seemingly unconscious innuendo. This was accompanied by personal attacks, not only upon the miners' leaders but upon other members of the Commission, including the blameless Sir John Sankey.

Meantime the Government continued to give no indication of its policy, and the period of waiting—interrupted only by the result of the Bothwell by-election when in spite of the 6s. rise the electorate declared for nationalisation and elected Mr. John Robertson, President of the National Union of Scottish Mineworkers—was spun out until the third week of August.

The Government Turns Down Nationalisation.

On the 18th August, at the end of the Parliamentary Session, Mr. Lloyd George made a long speech, in the course of which he announced the Government's policy, or rather its intentions, towards the coal mining industry. The speech was rather in the nature of a political manifesto. No Bill was tabled which would definitely carry out any of the proposals of the speech as regards mining, nor indeed were the more important proposals put in a concrete form. It did not bind Mr. Lloyd George to anything precise or definite.

Mr. Lloyd George began by stressing the fact that the Government were not bound to accept the Report of a Royal Commission—to which Mr. Adamson interjected "unless the Government promised to do so." The Premier went on to say that the value of the Coal Commission was detracted from by the fact that two of its members left the seat of judgment to go into the witness-box and that this was unprecedented.* He then stated that on one or two points, such as the State ownership of royalties, the Government proposed to act on the recommendations of the Commission, but that on the main question the Government were not going to accept the finding in favour of nationalisation. Almost the only reason he put forward for this attitude was that Mr. Justice Sankey had recommended nationalisation on the assumption that there would be a better feeling between the miners and the State than between the miners and profit-making private owners, and that since then there had been a strike—the Yorkshire strike—against the Government. That meant, he said, that industrial harmony would not come from nationalisation.

There are two questions to be examined in connection with Mr. George's speech. The first is, what are the changes he proposed to make? Second, was the decision to turn down nationalisation a breach of a pledge to the miners?

Mr. George's main proposals were summarised by himself as follows:—

"That the minerals are to be purchased by the State; that a fund should be raised for the purpose of promoting schemes for the social improvement and the amelioration of the conditions and the amenities of life in the mining villages; that the State should not purchase the business of the mines, and certainly not run them; that unification should be promoted by amalgamation in defined areas."

As far as the workers concerned they would have representation on committees locally; in the second place, they would have direct representation by the nomination of a certain number of directors on the boards, which would control the mines in each area.

There is a certain resemblance in this scheme to the recommendations of Sir Arthur Duckham; but, unlike Sir A. Duckham, the Premier made no mention of any provision (other than a vague generality that the Government would have power to overlook schemes in the interests of the consumer) by which dividends would be restricted. In fine, the Prime Minister's plan is not even for one national coal trust, but for a dozen or so gigantic combines which would benefit neither the nation nor the consumer, nor the miner. For it may be pointed out that the proposal to give the miners an effective voice in the control of the mines is in direct conflict with the position laid

* Mr. Lloyd George has got his facts wrong. Mr. Sidney Webb and Sir Leo Money would not have gone into the witness box unless there had been not one, but several, precedents. To take only one instance, that of the Royal Commission on Ecclesiastical Discipline, 1904-6, it is on record that a number of Commissioners, including the Archbishop of Canterbury, gave evidence before the Commission of which they were members.

down by the mine owners, to whose other demands Mr. George had completely surrendered. Their position was "if owners are not to be left complete executive control they will decline to accept the responsibility of carrying on the industry." Thus, if the miners are given an effective control, the coal owners will decline to co-operate. Either that or the proposed miners' share in control will be ineffective and a mere sham. Moreover, there is a growing repulsion amongst the miners to production for the profit of private individuals instead of for the advantage of the whole people. This growing feeling alone would make the Premier's scheme foredoomed to failure.

Did the Government Break their Pledge?

On this question there was an animated discussion in the House of Commons. It was pointed out that when the Bill setting up the Commission was before the House on February 24th, the Home Secretary had said with reference to nationalisation of mines—

It is a pure business proposition, and if it turns out on investigation that it is for the good of the country as a whole that the mines should be nationalised, that the people of the country would be better off if the mines were worked under a nationalised system, rather than under private ownership, then it is a good business proposition, and we should accept it. . . . The Government desire to go into the matter to see if it is a good business proposition. If it is that, I accept it. If it is proved to be a national detriment rather than a national advantage, then the Government will oppose it. There their position stands. I should have thought myself that for anyone who desired merely to do that which was best for the country, the proposal of the Government was the best, namely, that the whole question should be thrashed out with expert evidence, expert opinion, expert knowledge before a competent and highly efficient tribunal. So far for nationalisation.

Again, when the Miners' Federation met Mr. Bonar Law, the Leader of the House, on March 25th, at Downing Street, they were addressed by him as follows:—

I would like you, gentlemen, to consider, what do you gain by this Report? I do not know what you feel, but when this Commission was set up, I should have thought it impossible that you could have got without a strike, and at once, such a big step towards meeting your demands as you have secured. First of all, on the question of nationalisation, I know you attach—I believe, at least, you attach—as much importance to that almost, if not quite—as to improving your immediate conditions. Well, Mr. Justice Sankey has undertaken to report on that within two months—a very short time, I think—and it will be a report by people who have shown that they are not unsympathetic to the miners' demands. . . .

It was carefully explained by Mr. Bonar Law that these statements had not really committed the Government to nationalisation. But the suggestion which they conveyed was clearly that "if it turned out on investigation" that nationalisation was expedient then the Government "would accept it." It is beyond dispute that the Miners' Federation and the mining Members of Parliament on their part had gone away convinced that the Government would accept nationalisation if the Commission recommended it. It was on this understanding that the miners voted on the acceptance of the first (interim) Sankey Report. How strongly the miners felt about the Government's rejection of Mr. Justice Sankey's recommendation may be gauged from the words of Mr. Vernon Hartshorn in this same debate of August 18th. He said:—

We did not ask for a Commission.

We accepted it. We gave evidence before it. Why was the Commission set up? Was it a huge game of bluff? Was it never intended that if the reports favoured nationalisation we were to get it? Why was the question

sent at all to the Commission? That is the kind of question the miners of the country will ask, and they will say, "We have been deceived, betrayed, duped." The Prime Minister told us this evening that there were over 1,141,000 men in the mines, and that we should get about 200,000,000 tons of coal per year. Since the 6s. was put on the output had gone down, and is continually going down. I say after the declaration of this policy it will go down further to ruin. (Hon. Members: "Shame" and "Order! Order!") It does not in the least matter whether you cry shame or not. If it is to be a fact it is as well that you should know it—you people who have been bringing pressure to bear upon the Government. The shame will be with you when the position comes home to the miners of the country, and they will not in the least mind whether you say "Shame!" or not.

The Miners' Conference.

On 3rd September a full delegate Conference of the Miners' Federation met to consider a resolution put forward by their Executive to meet the situation created by the Government's failure to accept the principle of rationalisation. Mr. Smillie in his speech pointed out that the Miners had accepted the Commission reluctantly and only because they believed that the Prime Minister was in earnest and would act upon the Report of the Commission.

Mr. WILLIAM BRACE, M.P., seconded by Mr. W. ADAMSON, M.P., moved the adoption of the Executive's resolution. The resolution, which ran as follows, was carried unanimously:—

"Being convinced that the Government's scheme is wholly impracticable for the future working of the mines, the Executive Committee recommends the Conference of Miners' Delegates to reject the Government scheme, and records its regret that the Government has no better scheme than the creation of great trusts to secure the economic well-being of the industry.

"We are convinced that the only way to place the industry upon a scientific basis for the purpose of giving the advantage of a maximum production to the community, consistent with the maximum economic and social well-being of the miners, is at once to introduce the scheme of nationalisation recommended by the majority of the Coal Industry Commission.

"We do not at this stage recommend the miners to take industrial action to secure the adoption of the Coal Commission Report, but we invite the Trade Union Congress to declare that the fullest and most effective action be taken to secure that the Government shall adopt the Majority Report of the Commission as to the further governance of the industry."

The Trades Union Congress.

In accordance with this decision, the following special resolution was submitted to the Trades Union Congress at Glasgow on Wednesday, 10th September:—

"(a) This Congress having received the request of the Miners' Federation to consider the Government rejection of the Majority Report of the Coal Industry Commission, and the adoption in its place of a

scheme of District Trustification of the industry, hereby declares that, in conjunction with the miners, it rejects the Government scheme for the governance of the industry as a scheme contrary to the best interests of the nation, and it expresses its resolve to co-operate with the Miners' Federation of Great Britain to the fullest extent, with a view to compelling the Government to adopt the scheme of national ownership and joint control recommended by the majority of the Commission in their Report.

“(b) To this end the Congress instructs the P.C., in conjunction with the Miners' Federation, to immediately interview the Prime Minister on the matter, in the name of the entire Labour movement, to insist upon the Government adopting the Majority Report.

“(c) In the event of the Government still refusing to accept this position, a Special Congress shall be convened for the purpose of deciding the form of action to be taken to compel the Government to accept the Majority Report of the Commission.”

The resolution was moved by Mr. SMILLIE, seconded by Mr. J. H. THOMAS, M.P. It was opposed by Mr. HAVELOCK WILSON, M.P. The result of the voting was a 55 to 1 majority.

For the Resolution	...	...	...	4,478,000
Against	...	...	...	77,000
				<hr/>
Majority for	...	...	...	4,401,000

CHAPTER III.

THE CASE FOR PUBLIC OWNERSHIP.

It has already been made sufficiently clear that the main business of the second stage of the Commission was the discovery of a practicable alternative to private ownership. It is important to realise that expert opinion, as represented by official witnesses without any personal interest in the coal industry, was overwhelmingly against the present system, and in favour, on grounds of economy and for the sake of the consumer, of unification. Sir Richard Redmayne, who had declared the present system to be "extravagant and wasteful" during the first inquiry, reiterated his statement during the second. Even before the Commission was appointed, officials in the Coal Controller's Office had been so impressed with the flagrant inefficiency of existing methods that they had of their own initiative prepared a scheme of unification. It was clear, moreover, that there were only two possible ways out: one a method of unification by the formation of a great capitalist combine, with or without the offer of some specious scheme of representation of miners amongst the directors; the other by national purchase. The former of the methods received singularly little support in the evidence. It found its issue in the hybrid scheme put forward by Sir A. Duckham.

On the other hand a vast deal of the evidence was taken up with the discussion of nationalisation and many schemes and arguments at once precise and comprehensive were submitted to the Commission.

It would be useless labour on my part to try to present these schemes and arguments in words other than those in which they are set forth. Accordingly the following pages give the case for nationalisation as put forward by two members of the Commission who gave evidence. Thereafter follows the reasons urged against direct State administration, and on behalf of a scheme of joint management by Councils equally representative of the workers and of the State. These are taken principally from the evidence of Mr. G. D. H. Cole and Mr. William Straker.

The Postulates of an Efficient Coal Industry.

Mr. Sidney Webb, starting from certain postulates, showed that not only was the present system utterly unfit to meet these needs, but that no system other than public ownership could meet them adequately. Part of his evidence ran as follows:—

To the economist of to-day, as to the statesman, an efficiently directed industry of coal supply which would be one which:—

- (a) Provided for all the persons engaged in the industry the essential conditions of a civilised life, full opportunity for individual development and civic efficiency, so far as was compatible with the necessary conditions.
- (b) reduced to a minimum the number and gravity of the casualties incidental to the industry, and the impairment of health by its special diseases;

- (c) produced the required amount of coal when and where it was wanted with the greatest regularity and the smallest possible efforts and sacrifices of those engaged—which (and not the amount of wages or salaries) the economist means by “cost of production”;
- (d) made as economical as possible a draft on the nation’s irreplaceable resources in coal.

It is on these four points that the present system of administration of coal mining and coal distributing is (here the witness adopts the weighty judgment of Sir Richard Redmayne, the experienced Chief Inspector of Mines) “extravagant and wasteful”—alike as regards human life and personal development, as regards the nation’s coal, and as regards expense to the consumer. It is submitted that the cause of this waste and extravagance is the present system, or absence of system, which makes the management of coal mining, the marketing of the coal, and its retail distribution, the sport of individual enterprise and competition for profit, without union of aim or co-ordination of effort, each of the jostling rivals seeking, and being tested by not public service but merely private gain. Whatever advantages this chaos of private interests may have—perhaps in stimulating the wits of the capitalist competitors and lessening their indolence—its drawbacks in the coal supply have been made sufficiently manifest to have led the Government, in explicitly accepting the Chairman’s Interim Report of March 20th, to commit itself unequivocally to the policy of a national unification of the colliery enterprises. This being the case, the witness submits that only national ownership can meet the necessities of the position. Nationalisation is called for (1) as the only means of adequately improving the conditions of the miners with regard to housing, accidents and special disease, and infantile mortality; (2) as the only means of dealing economically and efficiently with the nation’s coal resources, and (3) as the only means of ensuring that the coal is supplied to the consumers with regularity and at the lowest cost.

HOUSING.

The housing conditions of the mining population, which constitute a grave national peril, can only be effectively dealt with by a public authority of national scope. No business considerations will ever warrant each colliery enterprise erecting decent cottages near each pit, many of which may be expected to be worked out within a short term. The same reasons apply to prevent any prudent Rural or Urban District Council from taking action on any considerable scale—even if it were to the pecuniary interest of the locally influential colliery enterprise, to encourage any such outlay of the rates. Nor is it fair to throw the whole cost of housing of such a special population on the ratepayers. Like extraordinary traffic on the roads, it is a case for the industry bearing its own burden. What is wanted is a prompt expenditure of something like ten or twelve million sterling; the planning of a whole series of well designed new villages, placed in situations easy of access to the whole of each part of the coalfield; and built at the cost of a National Housing Fund provided by the mining industry as a whole. It would plainly be impracticable to arrange for such a subsidy whilst leaving private colliery owners, whether separately or united in any capitalist trust, to reap the pecuniary profits.

A TAX ON ROYALTIES.

Such a Miners’ Housing Fund, moreover, must not be provided, any more than any other national purpose should be paid for by a tax on coal, even of only a penny a ton. Such a tax, and such a method of raising the funds, must be condemned as unscientific and contrary to sound canons of taxation. By raising the price of coal, it would make the poor man contribute almost as much per annum as the rich; and it would also by so much tend to diminish our export trade. A better method, it is suggested, would be to charge the Miners’ National Housing Fund on the Mining Royalties, when these are for other reasons made national property. . . .

ACCIDENTS.

It is not usually realised that, as has been said, the miner is always “in the trenches.” Last week, even without any big explosion, there will have been over 3,000 serious casualties in the mines of Great Britain: this is the average number officially reported each week as serious enough to involve absence from work for at least seven days (some five and twenty being fatal). Public attention is fixed on explosions of firedamp or coaldust, sometimes killing men by scores or hundreds; but these are the least of the dangers. Far more serious are the falls of side or roof, occurring to somebody’s grave hurt at the rate of nearly 200 every day in the year, and accounting for 600 deaths and 62,000 serious injuries annually. Shaft accidents take place two a day, killing a couple of men daily, and gravely injuring several others.

In addition, more than 25,000 men and boys are maimed or crushed, annually (and over 200 killed), by being run over underground by trams or tubs, and over 75,000 more suffer injuries incapacitating them for over seven days (some 200 being killed) by accidents classed only as "miscellaneous." We are, in the case of the miners, "coining their blood for drachmas." The liability to accident in the different coalfields varies considerably—partly, no doubt, by reason of differences in the character of the coal and the adjacent strata, but partly also, it cannot be disputed, by reason of differences in methods of working, in the extent to which mechanical safeguards are provided, in the precautions taken, and in the vigilance of the inspection. The South Wales coalfield has by far the worst record, not only for accidents from explosions and those from falls of side or roof, for which there may be some excuse in the character of the strata, but also for those from being run over by trams or tubs, a fact which demands explanation; the Yorkshire coalfield disputes the bad eminence of South Wales in the number of accidents from falls of side or roof; the Scottish coalfields vie with that of Yorkshire in being the worst for shaft accidents; whilst the Northern coalfield, which (perhaps for geological reasons) suffers least from falls of roof, comes out best at all points. Places of greater risk ought to be places of great precaution. If all the coalfields of the kingdom could be made only as safe as those of Northumberland and Durham, the nation would save annually three or four hundred miners from death, and probably thirty to forty thousand from serious injury.

PROFITS A CAUSE OF ACCIDENTS.

It is not contended that all accidents can be avoided; but it is a grave fact that, under private ownership, the pecuniary interest of the colliery shareholders is permanently against the adoption, in their entirety, of the safeguards that the Home Office recommends; and the very fact that the coalowners naturally resist such improvements—are, in fact, slow to believe that such costly changes can constitute improvements—inevitably causes the Home Office to be reluctant to recommend all that it would wish to do. It will not be denied that the 3,300 collieries differ much among themselves in the extent of their mechanical safeguards against accidents; meaning that the worst are, in the conditions of safety, far below the level of the best.

Moreover, with colliery agents, pit managers, and deputies or overlookers keenly aware that the working expenses must be kept down, it is impossible to secure sufficient thought or care, and sufficient expenditure on the stricter supervision and more adequate precautions that would, so the miners believe, prevent a large proportion of the casualties.

A whole generation of financial experience of the Employers' Liability Act—a couple of decades of the Workmen's Compensation Act—have demonstrated a fact of momentous significance, namely, that it usually costs less to compensate for accidents than to prevent them. This applies equally to a capitalist trust and to separate ownership.

It is submitted that it is not easy to avoid the inference that a certain proportion of the 3,000 accidents per week are, in these ways, directly attributable to dominance of the profit-making motive, involved in the private ownership of the collieries; and that this proportion, at least, will not be avoided until the private ownership, however much it is unified, has been got rid of. The miners have at least some ground for their firm belief that a nationalised administration would (a) make general at all mines all the mechanical safeguards already in use at the best of them; (b) render easier the adoption of new safeguards and precautions; and (c) diminish risks by lessening the strength of the plea that accidents cost less than prevention.

INFANT MORTALITY.

4. It is not a small matter for the nation that the miners, as a whole—one-tenth of the entire community—have the highest infantile mortality of any section, namely, 160 per 1,000 births—as compared with only 16.9 for agricultural labourers as a whole, and with 76.4 for the upper and middle classes (Report of Registrar-General for 1911, Table xxviii, p. xli). Why do twice as many babies die in a miner's cottage as in a middle-class home? That it is not poverty nor mere overcrowding in insanitary hovels, nor yet any exceptional ignorance of the girls who marry miners, which is the cause, is shown by the fact that the agricultural labourer's babies, even with the wages of 1911, die at only two-thirds the rate. The gravity of the evil is, of course, not merely or mainly that so many babies die. The causes that kill so large a proportion inevitably damage those who survive. It is not the infantile death rate, but the damage rate among this one-tenth of all the nation's children that the excessive death rate, infallibly indicates, which is of the greatest moment.

It is submitted that the outstanding cause of the difference between the whole class of miners and the whole class of agricultural labourers in all the counties of England and Wales is to be found in the special conditions of the miner's home—the dirt that he and his sons bring in every day; the discomforts of his washing all over in the one room available for the family; the hanging up to dry of the wet and grimy pit clothes; the exceptionally hard work imposed on the miner's wife, not lessened by the habit of more than the average number of children.

Of course, this is no concern of the colliery shareholders and directors under the present system of private ownership and management for pecuniary profit. It would be equally outside the ken of a capitalist trust. Only a Ministry of Mines, responsible to the nation for genuinely efficient administration from a national standpoint could take into account the effect that the industry was having on so large a proportion of the nation's children. . . .

A COAL TRUST IMPOSSIBLE.

It is submitted that there is no practicable remedy except national ownership. To merge all the 1,500 colliery concerns in a gigantic capitalist trust might be the means, if the trust were sufficiently large-minded and efficient, of remedying such of the waste and inefficiency as results from disunity. But—

- (a) it would not change the profit-making motive, and thus not solve the housing problem or that of the excessive infantile mortality;
- (b) it would still be cheaper for the trust to compensate for accidents than to prevent them;
- (c) a capitalist trust would have no more regard than the separate colliery owners for the most economical use of the nation's irreplaceable stores of coal;
- (d) it would still be up against the causes of waste and inefficiency incident (as Sir Richard Redmayne has demonstrated) to the present individual ownership of royalties.

A COAL LEVIATHAN.

What is even more important, to form a gigantic coal trust would be to commit both the industrial and the domestic consumer to the tender mercies of a monopolist who would have no other interest than to charge the utmost price that "the traffic would bear"; and to produce, not all the coal that could advantageously for the nation be consumed, with the regularity that would be most convenient, but such an amount only as would produce the greatest net income, even with any stoppages or irregularities that could be made the means of additional extortion. Witness believes that any proposal for a capitalist trust in coal, however camouflaged, would meet with the most strenuous opposition, not only from the Miners' Federation and the whole Labour Party, but also from the powerful co-operative movement, now beginning to have its own collieries, which would certainly refuse to enter such a combination; from industrial users of coal; and from the ten million domestic consumers. Such a proposal would be so universally unpopular as to bring down the strongest Government.

It may be urged that such a capitalist trust could be put under control; that a schedule of minimum wages and maximum hours could be imposed on it, together with a fixed maximum price. Experience shows that all such safeguards of capitalist monopoly are delusive. There are always a hundred and one ways in which they can be dodged; and no one would willingly put faith in the ability of a Government Department to outwit the profiteer. A single monopolist concern, having its tentacles in every constituency in the kingdom, with a million families on its payroll, would be far too powerful a Leviathan to be dragged with a hook by the Home Office. From the standpoint of the consumer, such a monopoly would be scarcely less open to objection if it were, in an unholy profit-making alliance, the joint concern of the combined capitalists and the Miners' Federation. Finally, it must be pointed out that a Government which was administering a national system of railway and other transport, and also a national system of electricity generation, could hardly allow itself to be dependent, for the regularity of its indispensable coal supply, on a privately owned and administered coal trust—which might any day get into difficulties, either with Labour or by mechanical or administrative breakdowns—and against which it would have constantly to pit its official brains to avoid being "done" in the price. There is thus, politically, no alternative to national ownership. . . .

FUTURE ORGANISATION.

- (e) Among the principal branches of the Ministry of Mines should be those of—
- (i.) SAFETY AND HEALTH, in which the present Mines Department of the Home Office would be merged, and greatly developed.
 - (ii.) RESEARCH, to be continuously at work inquiring alike into improvements of coal-getting and the treatment, transport, and using of coal; into the physiological, economic, and social problems of the occupation of coal mining; and into the commercial and financial aspects.
 - (iii.) SCIENTIFIC COSTING AND MEASUREMENT, for a continuous, accurate comparison, item by item, of every part of the operations and their results.
 - (iv.) EQUIPMENT AND STORES, for the common purchase and provision of everything that the most perfect equipment of the mines require.
 - (v.) ALLOCATION, controlling the supply of the coal to (a) the various Government Departments and local authorities, including the railway, canal, electricity, gas, tramway, and port administrations; (b) industrial users; (c) domestic consumers; (d) for export and bunkers.

Evidence of Sir Leo Chiozza Money.

In the evidence given by Sir Leo Chiozza Money, the case for the nationalisation of the Coal Industry is based upon the following grounds:—

- (a) The vital importance of coal in the national economy.
- (b) The need for the greatest possible conservation of coal.
- (c) The greater economy of united control, especially under nationalisation.
- (d) The superiority of public service, as compared with working for private gain, as an incentive and spirit in industry.
- (e) The recognition of the need to associate every person engaged in the industry with the conduct of its economy, as far as that is practically possible.

Of 15 reasons adduced by him in support of the first two grounds, the following selections are given. They emphasise the national importance of coal, and show how much waste of our coal resources occurs under the present system.

THE VITAL IMPORTANCE OF COAL IN THE NATIONAL ECONOMY.

2. Modern industrial wealth is for the greater part based on powers derived from coal, and Britain, the United States, and Germany alike have risen to industrial greatness because they happened to be the three greatest coal owning countries inhabited by white peoples. Between them they produced before the war more than 8 tons out of every 10 tons of coal produced by all the world. The history of the industrial revolution in Britain, which changed the poor agricultural state of the 18th century into the comparatively wealthy Britain of the 19th century, is also the history of our coal industry. The Commission is thus given the great responsibility of arriving at determinations which affect not a single trade but all trades, and, indeed, the degree of our future prosperity.

3. Coal is not only the greatest practical source of power yet known to science but, as was pointed out by Jevons, it acts as a magnet to raw materials because its bulk and weight make it most economically used at or near its place of production. Hence Britain, a small island with good ports, is an ideal workshop, since materials can readily be brought to its coal power. But the potency of coal in the national economy goes further; it is also the source of our shipping greatness, since it furnishes bulky outward cargoes to balance our bulky imports of food and materials, thus enabling our ships to earn money both inwards and outwards. But for coal our ships would largely go out in ballast, since, although our exports of manufactures are great their bulk or weight for value is comparatively small. Thus production, ample supplies of cheap materials, and shipping are alike seen to be based upon our coal mines. These things are well known to the Commission, and they are stated here in the briefest terms consistent with accuracy in order that all the aspects of the problem may have consideration in this evidence.

Perhaps I may remind the Commission that Jevons said that coal was almost of religious importance.

4. It is suggested that, in view of the primary importance of coal, without which these islands could not support more than one-third, if as many, of their present population, it is inconsistent with national safety and welfare for the ownership, control and disposition of our coal resources to be resigned to private interests, the irresponsibilities of which has abundantly appeared in the history of the trade. It is true that no evil exists to-day of the dimensions of the "limitation of the vend," which was so rigorously denounced by Porter in his 'Progress of the Nation,' and which for three-quarters of a century taxed our people and, by restricting coal production, frustrated British progress. . . .

THE ABSURDITY OF ROYALTIES.

Nevertheless, the spirit of commercialism which inspired that private system of taxation by coal producers remains and can only be exorcised by national dictation of what shall be done with national coal. As to the landowners' property in coal, it is indeed remarkable that a freeholder should be held in law to possess not only the fee simple of the surface but of whatever minerals may lie below it and at whatever depth they may be made available by science. As a wise and witty French economist Professor Charles Gide, of Paris University, has said, this absurdity "represents the landowner as possessing a pyramid, whose vortex is the centre of the earth, and whose sides are prolonged into infinity." The verities of physical science, indeed, are strongly at variance in this matter with the conceptions of property which have been erected into law by property owners.

5. The private ownership of that part of the interior of the earth which lies under the British area cannot, as it seems to me, be defended on any reasonable grounds, and I am strongly of opinion, therefore, that such ownership should be forthwith determined. It may be added that it would be at once equitable and a piece of good business for the nation to pay out the landlords, say at 10 years' purchase of existing coal rents and royalties, the State entering into possession of all minerals at present unworked or unproved. . . .

THE NEED FOR THE GREATEST POSSIBLE CONSERVATION OF COAL.

7. Of the three great coal nations Britain, the United States and Germany, our own country, unfortunately, has the smallest supplies of coal. Estimates of coal, especially in unproven fields, must necessarily be somewhat speculative, but there is no doubt that the following figures, which I have taken from the work of the last Royal Commission on the Coal Supply (1905), give a fair approximation of the facts of the case:—

COMPARATIVE COAL RESOURCES OF BRITAIN, THE UNITED STATES, AND GERMANY.

	Millions of Tons.
United Kingdom	146,000
United States	1,400,000
German Empire	415,000

In proved coalfields under 4,000ft. deep the estimate for Britain is 100,000 million tons.

Our duty plainly is (1) to conserve our coal by every possible means, and (2) to regard the remainder of the Coal Age as a period in which, by national organisation, and national training, to prepare our people for their coal-less future, whether that coal-less future results from the exhaustion of coal or the dethronement of coal. . . .

WASTE OF COAL.

9. The last Coal Commission had a good deal to say as to the waste of coal, and all that it said is, with negligible reservations, true to-day. The Commission pointed inter alia, to the following sources of waste in working as of importance:—

- (a) Much coal had been, and still was, being lost in barriers, although large area leases were tending to reduce that factor.
- (b) The establishment of central pumping stations would save much coal.
- (c) There was room for the application of better methods of working of thick seams.
- (d) Inferior and small coal was frequently left in the mines.
- (e) The advantages of the extended use of coal-cutting machinery were dealt upon, and figures given to show that in 1903 only five and a-quarter tons of coal were got by machinery. (This figure grew considerably in the war, but is still small.)
- (f) The use of hydraulic cartridges was referred to as being both safer than shot-firing and as preventing waste.

- (g) The use of electricity in mines was pointed to as invaluable both from the point of view of economy and efficiency.
- (h) It was indicated that there was room for economy in the preparation of coal at the pit-head.

The Commissioners also showed that the collieries are themselves amongst the greatest wasters of coal as users. They said "It is beyond question that collieries are extremely wasteful in the consumption of coal, no doubt to a large extent because of the small value of the fuel used, which is generally of very inferior quality." They went on to say, "It was stated by one of the witnesses that if the whole of the plant of the collieries were modern plant of the best description, the consumption of coal would be one half of what it is to-day." The consumption in question is 14 to 18 million tons per annum, or more than the whole production of India, Australia, or Canada.

WASTE THROUGH INEFFICIENCY OF INDUSTRY.

10. As to industry generally, a grave indictment was brought against the economy of private industry. It was shown that the consumption of coal per indicated horse power per hour was about five pounds, whereas it should not exceed two pounds, and might even be less.

"If all steam engines were as efficient as the best, 50 per cent. of the coal now used for steam raising might be saved."

That would mean a saving of about 26 million tons per annum. On this head the Coal Conservation Committee of 1918 said that "the present coal consumption would, if used economically, produce at least three times the present amount of power."

11. The Commissioners also referred to the grave waste in the coke manufacture, and spoke of the "prejudice against by-product coke ovens being overcome." Unfortunately this prejudice had been so little overcome at the time the war broke out that the nation found itself in grave lack of valuable by-products which it needed for war purposes and which, of course, are equally valuable for peace purposes.

12. The waste of fuel in our iron and steel manufactures is worth particular attention. It will be remembered that evidence was given to us to show that four tons of coal were needed to make one ton of steel. I was able to show that such a consumption was unnecessary in the best modern plant. This was also pointed out in an Appendix to the Report of the Coal Conservation Committee, consisting of a Memorandum by Mr Benjamin Talbot, who showed that under good modern practice the total fuel required per ton is only 35 cwts. Professor Bone puts the figure at 1.6 tons of coal per ton of finished steel.

13. The Coal Conservation Committee of 1918, under Lord Haldane, dealt in particular with the great advantages to the national economy which would arise from the creation of great central power stations, which, it was held, would save 55 million tons of coal per annum in respect of power purposes alone, to say nothing of domestic uses or of the possibility of extracting valuable by-products before consuming the coal for power purposes.

UNEXPLORED COALFIELDS.

14. Not less remarkable than the waste in getting coal and the waste in coal actually got, is the national neglect to explore our coalfields. Professor W. W. Watts devoted his presidential address to the Geological Society of London in 1912 to this important subject. He pointed out how much coal had already been wasted through the imperfect working of rich areas, through the neglect of drainage, etc., and other causes, and pleaded for a systematic survey of our coalfields as a national necessity and as a profitable investment. He referred to the fact that in Eastern and Southern England there exists a great area of covered Palæozoic rocks which ought to be explored "by means of a considered series of borings." Thus, as he said, "would introduce a new practice into British institutions," but similar methods have been employed abroad. He added "It is urged that the close dependence of the future of the nation on its coal supplies justifies a new departure, and that it would be a wise act of statecraft to take deliberate measures to devise a comprehensive and well considered scheme of exploration, the results of which might be at hand for application before the growing scarcity of coal shall have begun to produce its inevitable economic consequences upon the manufactures and upon the very conditions of existence in this country."

15. I think that the cumulative effect of these many considerations is to point to the urgent necessity to take national control of our power resources, that we may make quite sure that nothing is left undone to utilise every factor of economy to the highest possible degree. The matter is too grave to be entrusted to many different hands working in many different ways, and actuated mainly or solely by motives of present private profit.

CHAPTER IV.

THE CASE FOR DEMOCRATIC CONTROL.

Mr. William Straker, the Secretary of the Northumberland Miners, who had been responsible to the Miners' Federation for the drafting of the Parliamentary Bill in which provision was made for joint control by the workers and the State, gave evidence again in the second stage. I quote from his evidence a passage which shows more clearly than anything else that the difference between the two sides is at bottom a difference of outlook. From this passage it can be seen that the quarrel between profit-makers and the miners is irreconcilable in so far as the two parties have different philosophies of life. Mr. Straker said:—

FUNDAMENTAL DIFFERENCES.

"It is well," says one great thinker, "that the beaten ways of the world get trodden into mud; we are thus forced to seek new paths." Notwithstanding the mud, any section of mankind which has done well for itself along the old ways will always be reluctant to leave these ways.

During the first stage of this Commission the old ways of mine management and control were shown to be so beaten into mud that the report, known as the Sankey Report, and accepted by the Government, declared that "the present system stands condemned." This being so, we must have a new system; not a mere patching up of the old, such as is suggested by the scheme of the mine owners.

It is well that we should narrow down to a clear issue the fundamental difference between those for and those against nationalisation. Those against nationalisation evidently hold that competition is the very soul of progress. Life, to them, is an antagonism, each individual struggling for supremacy; and out of this struggle the fittest will survive. This means that out of selfishness, scientifically applied, will come the greatest good to the greatest number. This seems to me to be a primitive idea belonging rather to an early form of society than to the 20th century civilisation.

On the other hand, those in favour of nationalisation hold just as strongly that life is not necessarily an antagonism, and that mutual aid, applied scientifically, must give the best results. This is a conception which mankind arrives at after getting away a considerable distance from the primitive. Selfishness is the root cause of all wrong-doing; therefore any system which is an outgrowth of selfishness must be wrong. That which is morally wrong cannot be economically right. Systems based upon this great truth ought to be encouraged, as such must produce a better citizen. Systems based on the desire for selfish gain ought to be discouraged, as making for all that is worst in individual and corporate life. That which draws men together in co-operative activities makes for progress and human welfare; that which keeps men in a hostile attitude one to another wars against welfare and progress.

NATIONALISATION.

No industry ought to be carried on only for the benefit of those engaged in it; it ought to be for the benefit of the whole community. This is a truism which very few will dispute. Under private ownership of industry the primary object is private gain, the welfare of the community being a secondary consideration. In the development of human society private industrial enterprise has played a valuable part. But as soon as the community can manage an industry, necessary to its own welfare, it should no longer be owned and controlled privately. Private ownership, then, having served its day should cease to be. This applies with equal force to other industries than mining; but for the time being, and sufficient for the time, we are dealing with the latter industry.

Mining can be more economically carried on by the executive power of mining being in the hands of those engaged in it, and who, as a matter of course, must know most about it, instead of, as at present, by so many people such as shareholders and directors with no practical knowledge, who so largely dominate mining policy at the present time.

Not only this, but the huge drain upon the industry by royalties, rents, and wayleaves would disappear, and the large private profit would, in one form or another, go to or remain with the people generally.

THE RESULTS.

The inevitable results of nationalisation would be:—

1. A decrease in cost of production decreasing the price of coal (a) to the consumer at home, (b) for export.

2. As a result of the decreased price at home many other national industries dependent upon a cheap supply would be largely benefited.

3. The decreased cost for export would lead to an increase in the quantity exported.

4. This would tremendously benefit the shipping trade. This increase in export coal shipments would prevent any ships having to sail outward with, possibly, only ballast, with the consequence that the homeward freight would be reduced, as it would not have to cover both the homeward and the outward voyage.

5. Decreased freights would in turn produce a decreased cost of the commodities imported, and in particular of the country's raw materials and food.

6. In addition to these benefits, the State would own its own mines and minerals, and would have the results accruing from such ownership instead of, as at present, only receiving a part in the shape of income tax and mineral rights duty.

Mr. Cole's Evidence.

This difference of outlook was set forth in more detail by Mr. G. D. H. Cole, who, as Honorary Secretary of the Labour Research Department and Executive member of the National Guilds League, appeared before the Commission and gave support to Mr. Straker's scheme for control by the workers. The précis submitted by Mr. Cole is given almost in full, as it may be regarded as a classic statement of the case for industrial democracy:—

5. My reasons for desiring a system of ownership and control similar to that advocated by Mr. Straker fall under a number of heads:—

(a) Reasons for desiring direct and adequate participation by the workers in the management

(b) Reasons for desiring participation of persons nominated by the State in the management.

(c) Reasons for desiring national ownership.

REASONS FOR WORKERS' PARTICIPATION.

6. The workers employed in and about collieries should assume a direct and increasing share in the management, not only in order that the principles of democracy may be applied to industrial organisation, but also in the interest of the consumers and of the community. We have reached a stage in certain vital industries, including coal mining, if not in industry as a whole, when the workers will no longer consent to remain within the boundaries of the wage system.

7. By the wage system I mean a system under which the worker sells his labour to an employer in return for a wage, and by this sale is supposed to forego all right over the manner in which his labour is used within the terms of the wages-contract, all right to exercise control over the management of the industry or service in which he is engaged, and all claim to the produce of his labour or of the common product of the labour of himself and his fellow workmen.

8. Thanks to the growing strength and consciousness of Trade Unionism, this wage system is no longer fully and completely operative. Trade Unions do constantly, by collective regulation of the conditions of labour, by collective bargaining, and by strikes, exercise a certain control over the way in which the labour of their

members is used, and even over management. But, excluded from direct participation in management and control, Trade Unions and workmen are confined in the main to the imposition of negative forms of control, i.e., virtually to a veto on certain methods of using and organising labour. Such negative regulation inevitably tends to take a restrictive form, which becomes more severe as Trade Unionism becomes stronger, until it threatens to break altogether the system—the wage system—in which it is enclosed.

9. In the words of the memorandum submitted by the Labour representatives to the recent Industrial Conference, "Labour has now grown too strong to be controlled by force or compulsion of any kind." The method of destroying Trade Union "restrictions" by a frontal attack upon Trade Unionism is therefore not only undesirable, but in practice impossible. The only alternative is a frank acceptance of Trade Unionism, and an endeavour to convert the negative (and therefore partially restrictive) control which it now exercises into a positive (and therefore co-operative) control.

10. In other words, the problem of industry at the present time—and of the coal mining industry in particular—is to enlist the active co-operation of the workers and of their Trade Unions in making the industry as efficient as possible.

11. This involves the establishment at once of the greatest amount of industrial democracy (that is, of direct control by the workers and their Trade Unions) that is immediately practicable, and the most rapid extension of that control that is practicable subsequently.

12. Such control is not only, or mainly, a question of wages, hours, and conditions of labour as ordinarily understood; it includes the whole conduct of the industry, both in its productive and in its business aspects. Especially does it include the whole domain of financial and productive management and of supervision.

13. I am not unmindful of the enormous importance of technical and expert assistance, both in normal mining operations, and more especially in carrying out the great changes that are necessary in connection with the reorganisation of the industry. But I am of opinion both that technical and expert assistance can be combined with control by the workers at least as well as with control by private capitalists, and indeed that the natural affiliation of the brain-worker is with the manual worker rather than with the capitalist. To this point I shall return at a later stage.

14. In short, from the point of view of the coal consumer and of the community as a whole, the only way of securing efficiency in production—perhaps the only way of securing at all the continuance of industry—is to enlist the active co-operation of the workers by agreeing at once to the assumption by them of a substantial share in control.

THE CASE FOR INDUSTRIAL FREEDOM.

15. I shall now attempt to state the case for direct participation in control from the standpoint of the worker himself. Human freedom, where it exists, is not a name, but a living reality. It implies, not the absence of discipline or restraint, but the imposition of the necessary discipline or restraint either by the individual himself, or by some group of which he forms, and feels himself to form, a part. A democratic or "free" system of government is one in which every individual not only has a share or vote, but also feels that his share or vote is of some effect by virtue of his community with his fellow sharers or fellow voters.

16. This principle of freedom should apply to industrial organisation, which forms in a modern community so important and so insistent a part in a man's life. It does not apply under the existing system of conducting industry; and it cannot be made to apply fully in a day or a year. But it should be our object to apply it as fully as we can, and ever more fully.

17. If, then, a man must receive orders, he must, if he is to be free, feel that these orders come from himself, or from some group of which he feels himself to be a part, or from some person whose right to give orders is recognised and sustained by himself and by such a group. This means that free industrial organisation must be built on the co-operation, and not merely on the acquiescence, of the ordinary man, from the individual and the pit up to the larger units.

18. Only the increasing adoption of this method of industrial organisation can give the sense of fair treatment and active co-operation to the worker, and thereby, through the removal of unrest and the stimulation of effort, efficient production and service to the consumer and to the community.

19. With the question of national ownership I deal at a later stage; but I desire to point out here, that national management by itself will not secure the full co-operation of the workers. State management means in practice management by

a State Department; and a State Department is not a "group of which the ordinary man feels himself to be a part." The workers under State management are no more free, so far as the conditions of their working life are concerned, than the workers under capitalist management. The question of joint control with the State is dealt with further below.

20. Joint control with the present owners or with the consumers would also be ineffective. The reasons for this are also dealt with below.

REASONS FOR PARTICIPATION BY THE STATE.

21. The "control of industry" includes two distinct functions, the actual management of productive and distributive enterprise and the ultimate financial control. I desire to deal with these separately.

22. The reasons for State participation in actual management are, to a considerable extent, of only temporary validity. If the whole effective working personnel of the mining industry were combined in a single group possessed of a feeling of community, and including not only the workers and clerks, but also all the supervisors, professionals, and experts necessary to the conduct of the industry, direct participation by the State in the normal work of management would be unnecessary. It is my hope that this position will gradually be reached, and, to that extent, that direct State participation in management will be gradually withdrawn.

23. Until this becomes possible, the State should appoint as its representatives on the Mining Council (excluding for the moment those appointed to represent the consumers (persons of professional or expert knowledge of mining operations).

24. The function of the State, therefore, in relation to productive management, is mainly that of safeguarding the technical efficiency of the industry until the creation of a complete Mining Guild becomes possible.

CONSUMERS' REPRESENTATION.*

25. It is also suggested that the State appointments to the Mining Council should include persons specially appointed to represent the consumers. Whether this also would be a transitional measure, I am unable to make up my mind. It is, however, clearly necessary that the consumers of coal should have some means of ensuring that their views will be heard, especially in relation to questions of coal distribution and the allocation of supplies to various districts.

FINANCIAL CONTROL.

27. I come now to the question of ultimate financial control. This involves (a) scrutiny of the balance sheet of the Mining Council, (b) ultimate control of prices, (c) provision of capital, (d) utilisation of the balance of revenue over expenditure, and (e) methods of appropriations, redemption, etc.

23. These are functions which concern the State as the representatives not of the consumers but of the community as an association of neighbours or citizens. Whatever may be the future structure of political society, they are for the moment functions properly to be exercised by the people's representatives in Parliament.

29. At the same time, the existing organisation of Parliament does not provide for their satisfactory exercise. I suggest a Committee of the House of Commons, presided over by the Minister of Mines, to consult with the Mining Council, and to take administrative action in these matters, subject to the sanction of the House as a whole.

30. This implies that any surplus of mining revenue over expenditure, or expenditure over revenue, will pass into the Budget, and that any fresh capital required, whether raised by special mining stock or otherwise, will be provided by the State. At the same time, the general financial management must be in the hands of the Mining Council.

31. Both the Mining Council and the proposed House of Commons Committee are often criticised on the ground that they undermine "Ministerial responsibility." May I respectfully record my conviction that, under existing conditions, "Ministerial responsibility is mostly moonshine?"

* At a later stage Mr. Cole accepted Mr. Arthur Greenwood's proposals for a special Coal Consumers' Council. This is provided for in the Miners' Bill, printed as an appendix.

THE AVOIDANCE OF BUREAUCRACY.

32. The objections brought against national ownership are usually for the most part objections to bureaucratic control. The above considerations, which presume national ownership, show that there is no necessary connection between it and bureaucratic control.

33. National ownership of the mines is necessary for three principal reasons; (1) for the sake of the community, in order to secure the fullest utilisation and conservation of a vital natural product in the common interest; (2) for the sake of the consumer, in order to prevent exploitation and profiteering; (3) in order to give the workers the sense of working for the community and not for the benefit of any private person.

34. Full utilisation and conservation of our coal resources can only be secured by unified working and real unification of working can only be secured by unified ownership.

35. This only leaves the two alternatives of a gigantic private trust or monopoly (either under private control or otherwise) or of national ownership.

36. A coal trust not under public control is obviously out of the question.

37. Wartime experience of State control without ownership has proved the impossibility of either effective or efficient control without ownership. Control without ownership involves huge waste by the duplication of administrative machinery.

38. Moreover, in controlling prices without ownership the State continually falls between the two stools of cheapness and plenty, if it restricts prices, output is restricted; if it fosters output, it can only do so by permitting high prices. The retention of the motive of profit-making as the incentive in industry renders efficient State control impossible.

39. In addition, the full co-operation of the workers by hand and brain can only be secured if they feel they are working, not for private profit, but for the benefit of the community. Just as national ownership is inadequate without workers' control, so workers' control is inadequate without national ownership.

40. It has been suggested that the full co-operation of the worker could be secured by a system of joint control between owners and workers. But real control by the workers is impossible as long as the industry continues to be conducted for the private profit of the owners alone.

NO PROFIT-SHARING.

41. Where this is recognised, it is sometimes suggested that the workers might be given, in law or in fact, a share in the ownership by some system of individual or collective profit-sharing or co-partnership.

42. In my opinion, this would not work in practice, because the motives of the owners and workers are irreconcilable within the system of private ownership.

43. Even if it could be brought into operation, its effects would be anti-social; for the profit-making is not improved merely by increasing the number of shareholders. The coal industry requires to be worked as a national service, free from the motive of profit-making.

44. In any case, it is hardly necessary to discuss this question in detail; for it would certainly be rejected by the miners, and as it has only been devised in the hope of making possible the continuance of private ownership, it would thereby fall at once, if it has not already fallen, to the ground.

EXPROPRIATION AND COMPENSATION.

45. I do not desire to enter at all fully into this aspect of the question, on which I am not an expert.

46. I desire, however, to emphasise my view that it would be wrong to compensate the owners of mines or minerals on the basis of their past or present commercial value.

47. My reason is, that this value depends upon the control which they have hitherto been able to exercise over labour. To the extent to which they have lost this control the commercial value of their property has become unreal, and they have no title to compensation in respect of such value. They must not be placed by compensation in a more secure or more favourable position than other capitalists, who are also losing their control over labour, on which their past profits have depended.

METHODS OF CONTROL.

48. As I have stated, I am in general agreement with the Scheme of Control put forward by Mr. Straker on March 14th. There are only two points which I desire to elaborate further at the present stage.

POSITION OF THE SALARIAT.

49. The first point concerns the position of professional, technical, and supervisory staffs. The members of these staffs can be rightly divided into two classes: (a) those whose function is mainly expert and (b) those whose function is mainly the supervision or direction of other men.

50. In the case of class (a) the principle of selection must be primarily based on "qualification" and expert knowledge. In the case of class (b) it must be based primarily on personality.

51. I hold strongly that those men whose business it is to mainly direct others should be chosen by those whom it is their business to direct, either by ballot or through a Committee of Selection or a Trade Union.

52. Were persons whose function is mainly directive must also possess technical or professional qualifications, the range of choice should be restricted to persons possessing the necessary qualifications; but the principle of selection from below should be preserved.

53. There is not the same reason for the adoption of this course in the case of persons whose function is mainly or exclusively expert and advisory.

LOCAL AUTONOMY.

54. The second point concerns the question of centralisation and local initiative in control. I hold strongly that the full co-operation of the workers can only be enlisted by a system of control which is largely localised, and includes a considerable element of direct control by the workers in each particular pit. A system of joint control nationally, or even nationally and in the proposed districts, will not be effective unless it is combined with a system of pit control.

55. At the same time, pit control will probably not at the beginning be capable of such full establishment as national and district control. It is therefore of the greatest importance that the system of control first established should be such as to admit of an increasing element of devolution both from the Mining Council to the district and from both to the pit.

CONCLUSION.

56. In conclusion, I desire to emphasise my agreement with the words of paragraph XV. of the Interim Report signed by the Chairman and by three other members of the Commission, that "it is in the interests of the country that the colliery workers shall in the future have an effective voice in the direction of the mine. For generations the colliery workers have been educated socially and technically. The result is a great national asset. Why not use it?"

I believe that these words can only be made good in fact by the adoption of national ownership combined with some such system of control as that which Mr. Straker outlined to the Commission.

CHAPTER V.

COMPARISON OF THE REPORTS AND THE MINERS' BILL.

Comparison of the Reports.

In the report of the six members it is stated that they consider that in order to secure "the cordial co-operation of the workers in the success of the industry, it is necessary to provide a fuller representation of the workers on the District and National Councils on the lines indicated in the scheme submitted by Mr. W. Straker." This scheme (as part of the draft Parliamentary Bill of the Miners' Federation) is printed as an appendix, but it may be useful to summarise the chief proposals of the Miners' Bill here.

The Miners' Bill is differentiated by its provisions for the nationalisation of all mines and minerals ~~forthwith~~; it allows no compensation to royalty owners; it expressly includes coke-ovens and by-product works, and it insists on the retention in a nationalised industry of the miners' full rights, political and industrial.

Administration.

Its scheme of administration is based on the vesting of all powers in a National Mining Council, consisting of the Minister of Mines for the time being and 20 whole time members, ten of whom are appointed by the Government and ten by the Miners' Federation. The composition of this body is intended to avoid a bureaucratic running of the mines, and this object is also sought in the institution of District Councils and Pit Councils with powers delegated from the Mining Council. In each case half the members are to be representatives of the working miners. In addition there is to be a Mining Conference and a Fuel Consumers' Council.

Comparison of Sankey Proposals.

The Sankey proposals and the Straker proposals each provide for national ownership and for the avoidance of bureaucracy by handing over administration to the District Councils.

Naturally, however, the Sankey scheme leaves the Minister for Mines in supreme control, with the obligation to consult the Standing Committee of the Mining Council on certain questions. The miners' scheme makes the Mining Council itself—the Minister of Mines being a member—the supreme authority.

The local bodies have their powers limited to advising the management under Sankey. In the scheme of the miners their powers are undefined.

The composition of all the joint bodies in the Sankey scheme is tripartite, the miners receiving a third or less, while the consumers are directly represented on both District and National bodies. Mr. Straker, for the Miners' Federation, proposes a dual composition of these bodies, the consumers

receiving their representation through a special body, the Fuel Consumers' Council. Lastly, the Sankey scheme proposes a form of binding contract for individual miners, while the Straker scheme expressly contends that there be no restriction of the miners' right to strike.

Apart from these differences, it is to be noted that in the desire to have done with the anarchy of private individualism on the one hand, and to avoid the rigidity of over-centralisation on the other, each scheme propounds district administration, and in each case through joint bodies.

Sir Arthur Duckham's Report.

Sir Arthur Duckham proposes that a commission should be set up to decide the areas into which the country should be divided. In each of these areas all the separate colliery companies were to be amalgamated into statutory companies, which would be guaranteed a minimum dividend of 4 per cent. by the Government. Profits in excess of 4 per cent. may be utilised first to form such reserve funds as may be approved by the Minister of Mines, and second to pay a further 2 per cent. dividend. Of all excess profits thereafter one-third would go to further dividend, but the remaining two-thirds must be used to reduce the price of coal.

It is clear that this scheme represents nothing more than the formation of a dozen or more coal trusts, each monopolist within its area. There is no guarantee that such a company would be compelled to improve the life of the workers, or that it would be effectually disabled from utilising the various financial devices by which men skilled in the art can evade the proposed restriction of profits.

The Coal Owners' Report.

The Coal Owners' Report stands for the retention of private ownership, and is thus in disagreement with the declared policy of the Government, which had adopted the Sankey interim report "in letter and in spirit." It proposed one of two modifications in the system, including the establishment of a sort of Whitley Pit Committee, consisting of equal numbers of representatives of the workers and of the management. Their views are perhaps best expressed, not in their own words but in those of one of the coal-owners, Lord Gainford, who, speaking as a witness, said:—

"I am authorised to say on behalf of the Mining Association that, if owners are not to be left complete executive control, they will decline to accept the responsibility of carrying on the industry, and, though they regard nationalisation as disastrous to the country, they feel they would in such event be driven to the only alternative—nationalisation on fair terms."

THE NATIONALISATION OF MINES AND MINERALS BILL, 1919.

[Certain important provisions are sidelined.]

A Bill to Nationalise the Mines and Minerals of Great Britain and to provide for the National Winning, Distribution, and Sale of Coal and other Minerals.

Whereas it is expedient that mines and minerals should be taken into the possession of the State.

Be it enacted by the King's Most Excellent Majesty, by and with the advice and consent of the Lords Spiritual and Temporal and Commons in this present Parliament assembled, and by the authority of the same, as follows:—

1. (1) For the purpose of winning, distributing, selling, and searching for coal and other minerals, there shall be established by His Majesty by Warrant under the sign manual, a Mining Council, consisting of a President and 20 members, ten of whom shall be appointed by His Majesty and ten by the Association known as the Miners' Federation of Great Britain.

Establishment
of Mining
Council.

(2) It shall be lawful for His Majesty, from time to time, to appoint any member of the Privy Council to be President of the Mining Council, under the name of the Minister of Mines, to hold office during His Majesty's pleasure.

(3) The Members of the Mining Council, other than the President, shall be appointed for five years, but shall be eligible for reappointment. Provided that His Majesty or the Association known as the Miners' Federation of Great Britain respectively shall have power to remove any person appointed by them and appoint some other person in his place. On a casual vacancy occurring by reason of the death, resignation, or otherwise of any of such members or otherwise, His Majesty or the Miners' Federation of Great Britain, as the case may be, shall appoint some other person to fill the vacancy, who shall continue in office until the member in whose place he was appointed should have retired, and shall then retire. The members of the Mining Council shall devote the whole of their time to the business of the Mining Council.

2. (1) The Minister of Mines and one of the Secretaries of the Mining Council (to be known as the Parliamentary Secretary and to be appointed by His Majesty) shall at the same time be capable of being elected to and of sitting in the Commons House of Parliament.

Minister of
Mines and
Parliamentary
Secretary.

(2) The Minister of Mines shall take the oath of allegiance and official oath, and shall be deemed to be included in the First Part of the Schedule to the Promissory Oaths Act, 1868.

(3) There shall be paid out of money provided by Parliament to the Minister of Mines a salary at the rate of £2,000 a year, and to the Parliamentary Secretary a salary at the rate of £1,500 a year.

(4) The Minister of Mines and the Parliamentary Secretary shall be responsible to Parliament for the acts of the Mining Council.

Officers, etc.

3. (1) The Mining Council shall appoint a Secretary (to be known as the Permanent Secretary), and such assistant secretaries and officers and servants as the Mining Council may, with the sanction of the Treasury, determine.

(2) Subject to the provisions of Section 11 (2) of this Act, there shall be paid to the Permanent Secretary, Assistant Secretaries and other officers and servants such salaries or remuneration as the Treasury shall from time to time determine.

(3) There shall be transferred and attached to the Mining Council such of the persons employed under any Government Department or local authority in or about the execution of the powers and duties transferred by or in pursuance of this Act to the Mining Council as the Mining Council and the Government Department or local authority may with the sanction of the Treasury determine.

(4) Notwithstanding anything in any Act, order, or regulation, any society of workers, all or some of whose members are wholly or partly employed in or about mines, or in any other manner employed by the Minister of Mines, or the Mining Council, or a District Mining Council, or Pit Council, or otherwise under this Act, may be registered or constitute themselves to be a Trade Union, and may do anything individually or in combination which the members of a Trade Union or a Trade Union may lawfully do. Provided further that notwithstanding any Act, order, or regulation to the contrary, it shall be lawful for any person employed under this Act to participate in any civil or political action in like manner as if such person were not employed by His Majesty, or by any authority on his behalf.

Provided, further, that no such person shall suffer dismissal or any deprivation of any kind as a consequence of any political or industrial action, not directly forbidden by the terms of his employment, or as a consequence of participation in a strike or trade dispute.

Constitution
of Mining
Council.

4. (1) The Mining Council shall be a Corporation to be known by the name of the Mining Council and by that name shall have perpetual succession, and may acquire and hold land without licence in mortmain.

(2) The Mining Council shall have an official seal, which shall be officially and publicly noticed, and such seal shall be authenticated by the Mining Council or a secretary or one of the assistant secretaries, or some person authorised to act on their behalf.

(3) The Mining Council may sue and be sued without further description under that title.

(4) Every document purporting to be an order, licence, or other instrument issued by the Mining Council, and to be sealed with their seal, authenticated in manner provided by this Act, or to be signed by a secretary or by one of the assistant secretaries, or any person authorised to act, shall be received in evidence and be deemed to be such order, licence, or other instrument without further proof unless the contrary is shown.

(5) Any person having authority in that behalf, either general or special, under the seal of the Mining Council may, on behalf of the Mining Council, give any notice or make any claim,

demand, entry, or distress, which the Mining Council in its corporate capacity or otherwise might give or make, and every such notice, claim, demand, entry, and distress shall be deemed to have been given and made by the Mining Council.

(6) Every deed, instrument, bill, cheque, receipt, or other document, made or executed for the purpose of the Mining Council by, to, or with the Mining Council, or any officer of the Mining Council, shall be exempt from any stamp duty imposed by any Act, past or future, except where that duty is declared by the document, or by some memorandum endorsed thereon, to be payable by some person other than the Mining Council, and except so far as any future Act specifically charges the duty.

5. (1) On and after the appointed day, save as in Sub-Section 3 of this Section, provided—

3
Transference of
mines and
minerals to
Mining Council.

(a) Every colliery and mine (including all mines, quarries and open workings of ironstone, shale, fireclay and limestone, and every other mine regulated under the Metalliferous Mines Regulation Acts, 1872 and 1875, but not including mines, quarries, or open workings of minerals specified in the First Schedule to this Act), whether in actual work, or discontinued, or exhausted, or abandoned, and every shaft, pit, borehole, level, or inclined plane, whether in course of being made or driven for commencing or opening any such colliery or mine, or otherwise, and all associated properties (including vessels, lighters, railway rolling stock, and all works, including works for the manufacture of bye-products, in the opinion of the Mining Council belonging to any mine undertaking or connected with any colliery or mine, and every house belonging to the owners of any such colliery or mine, which, in the opinion of the Mining Council, is usually occupied by workmen employed at such colliery or mine), (all of which are herein included in the expression "mine"); and

(b) all coal, anthracite, lignite, ironstone, shale, fireclay, limestone, or other mineral, excepting the minerals specified in the First Schedule to this Act, whether at present being worked or not worked, or connected or not connected with any mine, beneath the surface of the ground (all of which are herein included in the expression "minerals"); and

(c) all rights and easements arising out of or necessary to the working of any mine or the winning of any mineral, including all mineral wayleaves, whether air-leaves or water-leaves, or rights to use a shaft, or ventilation or drainage or other royalties, lordships, or rights in connection therewith, whether above or below the ground (all of which are herein included in the expression "rights")

shall be transferred to, vested in and held by the Mining Council in their corporate capacity in perpetuity, and shall for all purposes be deemed to be royal mines, and the minerals and rights thereof respectively.

(2) The Acts contained in the Second Schedule to this Act are hereby repealed.

(3) Provided that the Mining Council may at any time before the appointed day give notice in writing to the owner of, or

person interested in, any mine or minerals or rights, disclaiming, during the period of such disclaimer, all or part of the property in such mine or minerals or rights to the extent specified in the notice, and thereafter such mine or minerals or rights shall, until such time as the Mining Council shall otherwise determine, to the extent specified in such notice, not vest in the Mining Council as provided by Sub-Section (1) of this section. Provided that in such case it shall not be lawful for any person other than the Mining Council, without the permission of the Mining Council, to work such mine or minerals in any way. Provided further that on the termination of such disclaimer by the Mining Council, such mine or minerals or rights shall, to the extent of such notice, as from such date as the notice may prescribe, vest in the Mining Council as if such notice of disclaimer had not been given.

Purchase of
mines.

6. The Mining Council shall purchase the mines of Great Britain in them vested by this Act (other than those which are the property of the Crown at the time of the passing of this Act or which have been disclaimed in whole or in part in accordance with Section 5 (3) of this Act) at the price and in the manner provided by this Act. Provided always that the value of any rights as defined by Section 5 (1) (c) of this Act shall not be taken into account in computing such price, for all of which no compensation shall be paid.

Mines Commis-
sioners.

7. (1) For the purpose of assessing the purchase price of mines it shall be lawful for His Majesty, by warrants under the sign manual, to appoint ten Commissioners, to be styled the Mines Purchase Commissioners (herein called the Commissioners) of whom one, appointed by His Majesty, shall be Chairman.

(2) Three of the said Commissioners shall be nominated by the Association known as the Miners' Federation of Great Britain, and three by the Association known as the Mining Association of Great Britain.

(3) At the expiration of twelve months from the passing of this Act, in the event of a majority of the Commissioners failing to agree as to the purchase price of a particular mine or of its associated properties, it shall be lawful for the Chairman himself to fix the purchase price of such mine, which price shall then be deemed to be the price fixed by the Commissioners, but, save as herein expressly provided, the finding of a majority of the Commissioners voting on any question or as to the purchase price of mines shall be final and conclusive and binding on all parties.

(4) It shall be lawful for His Majesty to remove any Commissioner for inability or misbehaviour. Every order of removal shall state the reasons for which it is made, and no such order shall come into operation until it has lain before the Houses of Parliament for not less than thirty days while Parliament is sitting.

(5) The Commissioners may appoint and employ such assessors accountants, surveyors, valuers, clerks, messengers, and other persons required for the due performance of their duties as the Treasury on the recommendation of the Commissioners may sanction.

(6) There shall be paid to the Commissioners and to each of the persons appointed or employed under this section such salary or

remuneration as the Treasury may sanction ; and all such salaries and remuneration and the expenses of the Commission incurred in the execution of their duties, to such amount as may be sanctioned by the Treasury, shall be paid out of moneys provided by Parliament.

8. (1) The Commissioners shall, as soon as may be after the passing of this Act, cause a valuation to be made of all mines other than those disclaimed, whether or not developed or working or abandoned or exhausted, in Great Britain, showing what on August 4th, 1914, and what at the date of the passing of this Act was respectively the total ascertained value of each mine and its associated properties and the rights, as defined by Section 5 (1) (c) of this Act, therein, and the total ascertained value of such mine and its associated properties respectively exclusive of such rights; and the owner of every mine and any person receiving any rents, interest, or profit from any mine or possessed of any rights therein or connected therewith, on being required by notice by the Commissioners, shall furnish to the Commissioners a return containing such particulars as the Commissioners may require as to his property, rent, interest, profits, or rights in such mine.

Valuation of mines.

(2) The Commissioners may likewise cause any mine to be inspected, require the production of documents, or do any other thing which may, in their opinion, be necessary to fix the purchase price of the mine or its associated properties.

(3) The Commissioners in making such valuation shall have regard to returns made under any statute imposing duties or taxes or other obligations in respect of mines, or minerals or rights, and to any information given before or to any Commission or Government Department, including the Coal Industry Commission constituted under the Coal Industry Commission Act, 1919.

9. (1) The purchase price of mines exclusive of associated properties (other than mines in the possession of the Crown at the time of the passing of this Act shall be computed subject to the provisions of sub-sections (2) and (3) of this section by ascertaining the average annual number of tons of minerals actually raised during the five years preceding August 4th, 1914:

Ascertainment of purchase price.

Provided that as regards coal-mines in no case shall the maximum purchase price, exclusive of associated properties, be taken to be more than the following:

When 100,000 tons or less have been raised per annum on the average during such five preceding years, a capital sum equal to one such year's output at	...	...	...	12	0	per ton
When more than 100,000 tons have been raised per annum on the average during such five preceding years, a capital sum equal to one such year's output at	...	...	...	10	0	per ton

(2) The Commissioners in arriving at such computation shall also have regard to the actual gross and net profits which have been made in the mine during such years or thereafter and to the amounts which may have been set aside from time to time for depreciation, renewals, or development, and to the probable

duration of the life of the mine, and to the nature and condition of such mine, and to the state of repairs thereof, and to the assets and liabilities of any mine undertaking existing at the time of purchase which are transferable to the Mining Council under section 16 of this Act.

(3) Provided further that where a coal-mine, in the opinion of the Commissioners, has not been fully developed, the amount which would be raised under full development without any increase of capital expenditure shall be taken as the average annual number of tons raised, and the maximum purchase price in such case shall be taken to be a capital sum equal to the product of such number of tons and 12s. or 10s. per ton respectively, for the purpose of ascertaining the maximum value per ton under sub-section (1) of this section.

Issue of State
mines stock.

10. (1) The purchase price of any mine and such of its associated properties as have been purchased, as ascertained under the provisions of this Act, shall be paid by the Mining Council in mines purchase stock to the persons who, in the opinion of the Mining Council, have established their title to such stock. . Provided that an appeal shall lie to the High Court under rules to be framed by the High Court from the decision of the Mining Council as to the title of any such persons, but for no other purpose.

(2) For the purpose of paying such purchase price the Treasury shall, on the request of the Mining Council, by warrant addressed to the Bank of England, direct the creation of a new capital stock (to be called "Guaranteed State Mines Stock"), and in this Act referred to as "the stock," yielding interest at the rate on the nominal amount of capital equal to that payable at the date on which this Act received Royal Assent on what, in the opinion of the Treasury, is the nearest equivalent Government Loan Stock.

(3) Interest shall be payable by equal half yearly or quarterly dividends at such times in each year as may be fixed by the warrant first creating the stock.

(4) The stock shall be redeemed at the rate of one hundred pounds sterling for every one hundred pounds of stock at such times and by such drawings as the Treasury, on the recommendation of the Mining Council may think fit.

(5) The stock may be issued at such times and in such amounts and subject to such conditions as the Treasury may direct, and may be issued as bearer bonds with quarterly or half yearly interest coupons attached.

(6) The stock shall be transferable in the books of the Bank of England in like manner as other stock is transferable under the National Debt Act, 1870.

Powers of
Mining Council.

11.-(1) Subject to the provisions of this Act, it shall be lawful for the Mining Council to open and work mines and search for, dig, bore, win and deal with minerals and generally to carry on the industry of mining, distributing, vending, and exporting, together with all other industries carried on in connection therewith. Provided that it shall not be lawful for the Mining Council to lease or sell any mine or minerals or rights to any person, association, or corporation.

(2) The Mining Council may, from time to time, in such manner and on such terms as they think fit—

(a) subject to the general consent of the Treasury, appoint or continue in employment or dismiss managers, engineers, agents, clerks, workmen, servants, and other persons; and

(b) construct, erect or purchase, lease, or otherwise acquire buildings, plant, machinery, railways, tramways, hulks, ships, and other fixed or movable appliances or works of any description, and sell or otherwise dispose of the same when no longer required; and

(c) sell, supply, and deliver fuel, coal and other products, the result of mining operations, either within or without the realm; and

(d) enter into and enforce contracts and engagements; and

(e) generally do anything that the owner of a mine might lawfully do in the working of the mine, or that is authorised by regulations under this Act or by this Act; and

(f) employ local authorities for any purpose they may think necessary to carry out their duties under this Act, on such terms as may be mutually agreed.

(3) In addition to the powers conferred on the Mining Council by the last preceding sub-section, the Mining Council may, in such manner as they think fit, work any railway, tramway, hulk ship, or other appliance for the purpose of winning, supplying, and delivering coal or other products.

(4) The Mining Council may compulsorily purchase land or acquire such rights over land as they may require for the purpose of this Act, and shall have, with regard to the compulsory purchase of land, all the powers of purchasers acting under the Land Clauses Act, 1845, and the Land Clauses Consolidation (Scotland) Act, 1845, or any other Act giving power to acquire land compulsorily for public purposes, which may hereafter be enacted.

(5) With respect to any such purchase of land under the Land Clauses Acts in Great Britain the following provisions shall have effect (that is to say):—

(a) The Land Clauses Acts shall be incorporated with this Act, except the provisions relating to access to the special Act, and in construing those Acts for the purposes of this section "the special Act" shall be construed to mean this Act, and "the promoters of the undertaking" shall be construed to mean the Mining Council, and "land" shall be construed to have the meaning given to it by this Act.

(b) The bond required by Section 85 of the Lands Clauses Consolidation Act, 1845, and by Section 84 of the Lands Clauses Consolidation (Scotland) Act, 1845, shall be under the seal of the Mining Council, and shall be sufficient without sureties.

12. (1) The Mining Council shall, for the purpose of the carrying on and development of the mining industry, divide Great Britain into districts, and shall in each district constitute a District Mining Council of ten members, half of which shall be appointed by the Miners' Federation of Great Britain.

District Mining Councils and Pit Councils.

(2) The Mining Council may delegate to any District Mining Council or Pit Council, such of their powers under this Act as may conveniently be exercised locally, and the District Mining Council shall upon such delegation have and exercise within their district all the powers and duties of the Mining Council as may be delegated to them.

(3) A District Mining Council shall, subject to the approval of the Mining Council, have power within their area to appoint Pit Councils for each mine or group of mines, composed of ten members, half of which shall be members of the Miners' Federation of Great Britain, and nominated by the workers of the mine or groups of mines aforesaid, and the District Mining Council may delegate to such Pit Council such of their powers concerning the immediate working or management of a particular mine or group of mines as the District Mining Council may, subject to the approval of the Mining Council, think fit.

(4) The members of District Mining Councils shall be appointed for three years, but shall be eligible for reappointment, and the members of Pit Councils shall be appointed for one year, but shall be eligible for reappointment.

Fuel Consumers' Council and Advisory Conference.

13. (1) For the purpose of advising the Mining Council it shall be lawful for His Majesty to appoint persons, to represent the interests of consumers, to be known as the Fuel Consumers' Council.

(2) The Mining Council shall have power to convoke at such time as they think fit and under such regulations and conditions as they may prescribe advisory conferences of representatives of District Mining Councils, and the District Mining Councils shall have power in like manner to convoke advisory conferences of Pit Councils within their area.

(3) The expenses of the Fuel Consumers' Council, National and District Mining Conferences shall, subject to the approval of the Treasury, be paid by the Mining Council.

Payment of Mining Council and District Mining Committees and Pit Councils.

14. There shall be paid to each of the members of the Mining Council, other than the President, such salary as the Treasury may determine, and to the members of the District Mining Councils, and to the Pit Councils, such salaries and emoluments as the Mining Council, with the consent of the Treasury may determine.

Accounts.

15. (1) The Mining Council shall cause full and faithful accounts to be kept of all moneys received and expended under this Act, and of all assets and liabilities and of all profits and losses, and shall annually lay such accounts before Parliament

(2) The Mining Council shall annually cause a balance-sheet of accounts to be made, including a capital account and a profit and loss account for each mine worked under this Act.

(3) Such balance-sheet and statement shall be so prepared as to show fully and faithfully the financial position of each such mine, and the financial result of its operations for the year.

(4) All moneys raised under the authority of this Act shall, as and when raised, and all other moneys received hereunder shall,

as and when received, be paid into a separate account called " The National Mines Account."

(5) All moneys withdrawn from the National Mines Account constituted under this Act shall be withdrawn only by the order of the Mining Council or such other person as the Mining Council may from time to time appoint:

(6) All moneys in the National Mines Account, or payable into that account by any person whomsoever, and also all moneys owing by any person under this Act, are hereby declared to be the property of the Crown, and recoverable accordingly as from debtors to the Crown.

16. (1) There shall be transferred to the Mining Council all the existing assets and liabilities of mine undertakings and associated properties, as and when they are transferred to and vested in the Mining Council, other than liabilities for rights including royalty rents, wayleave rents, or any other underground rents or charges, payable or due at the time of the passing of this Act to any person, all of which shall cease to be payable on and after the appointed day.

Transference of existing assets and liabilities.

(2) On the passing of this Act, there shall be ascertained by the Commissioners the amount of all moneys due to or from all mine undertakings, and the findings of the Commissioners as to the amount of such moneys shall be binding and conclusive on all parties.

(3) The net amount of all moneys due to any mine undertaking, after all debts due from any such undertaking have been deducted, as ascertained under Sub-section (2) of this section, shall be paid by the Mining Council to the persons to whom in the opinion of the Commissioners such debts are due, and shall be deemed to be expenses incurred under this Act. Provided that an appeal shall lie to the High Court, under rules to be framed by the High Court, from the decision of the Commissioners as to the title of any such person, but for no other purpose.

17. (1) All sums expended or payable under this Act in carrying out the provisions of this Act for expenses, or for salaries or wages payable under this Act, or in the construction, erection, or acquisition of buildings, plant, machinery, railways, tramways hulks, ships, or other appliances or works, or otherwise, shall be payable out of moneys provided by Parliament.

Payments-out of moneys provided by Parliament.

(2) Provided that moneys received under this Act in respect of the sale or export or supply of coal or other minerals (including the moneys received from the Government Departments) may be directly expended in or towards carrying out the purposes of this Act.

18. After full provision has been made for all outgoings, losses, and liabilities for the year (including interest on securities created and issued in respect of moneys raised as aforesaid, and on moneys paid out of the Consolidated Fund), the net surplus profits then remaining shall be applied in establishing a sinking fund and, subject thereto, in establishing a depreciation fund in respect of capital expended.

Payment out of Consolidated Fund.

Regulations. 19. (1) The Mining Council may, from time to time, make such regulations as they think necessary for any of the following purposes:—

- (a) The management of mines under this Act;
- (b) the functions, duties, and powers of the District Mining Councils, Pit Councils, and other bodies or persons acting in the management and working of mines or distribution and sale of fuel under this Act;
- (c) the form of the accounts to be kept and the balance sheets to be prepared in respect of mines under this Act;
- (d) the mode in which the sinking funds and other funds connected with mines under this Act shall be held and administered;
- (e) generally any other purpose for which, in the opinion of the Mining Council, regulations are contemplated or required.

(2) The Mining Council, before making or altering any regulations or conditions of employment, including wages, as affect workmen engaged in the mining industry, shall consult with the association known as the Miners' Federation of Great Britain, and, in the event of such representatives and the Mining Council failing to agree, the matter in dispute may be referred to arbitration on such terms as may be mutually agreed.

(3) Provided that nothing in this section shall be deemed to interfere with the right of any employed person, subject to his contractual obligations, to dispose of his labour as he wills.

Statutory regulations.

20. (1) Every mine worked under this Act shall be managed and worked subject to the provisions of the Metalliferous Mines Regulations Acts, 1872 and 1875, the Coal Mines Regulation Act, 1908, the Coal Mines Act, 1911, and any other Act regulating the hours, wages, or conditions of labour in mines.

(2) There shall be transferred to and be vested in the Mining Council all the powers and duties of the Secretary of State and of any other Government Department imposed upon them by the Metalliferous Mines Regulations Acts, 1872 and 1875, the Coal Mines Regulation Act, 1908, the Coal Mines Act, 1911, or any other Act regulating or affecting mines or the hours or conditions of labour therein.

Duty of Mining Council to supply coal.

21. (1) It shall be the duty of the Mining Council to ensure that there is a sufficient supply of fuel at reasonable prices throughout Great Britain, and for this purpose it shall be lawful for the Mining Council, or for any local authority or Government Department acting on their behalf, to establish stores and depots and to employ vehicles and to use all other necessary means for the selling of fuel and to sell fuel within the area of every local authority, and, further, for this purpose it shall be the duty of the railway companies or authorities of Great Britain to provide such facilities for the conveyance of fuel as the Mining Council may deem necessary to enable them to carry out the duties imposed upon them by this section at rates not greater than such railway companies or authorities are now entitled to charge for the conveyance of fuel.

(2) Where the Mining Council delegates to any local authority all or any of their powers under this section, it shall be lawful for such local authority to exercise all or any of the powers of the Mining Council so delegated to them.

(3) All moneys had and received or expended by a local authority under this section shall be deemed to be had and received or expended on behalf of the Mining Council.

22. This Act may be cited as the Nationalisation of Mines and Minerals Act, 1919, and this Act and the Metalliferous Mines Regulations Acts, 1872 and 1875, and the Coal Mines Regulation Acts, 1887 and 1908, and the Coal Mines Act, 1911, may be cited together as the Mines Acts, 1872-1919, and shall come into operation on the first day of the second month, which shall be the appointed day, after the passing of this Act, and, save in the case of disclaimer, all valuations, purchase, and transference of mines and minerals to the Mining Council, and all other arrangements for the carrying out of this Act shall be concluded on or before the first day of the second year after the coming into operation of this Act.

23. This Act shall not apply to Ireland.

FIRST SCHEDULE.

Minerals excluded from this Act :—

Sandstone.	Slate.	Building Clay.
Granite.	Chalk.	Gravel and Sand.
Cherts.	Flints.	Igneous Rocks.

SECOND SCHEDULE.

ENACTMENTS REPEALED.

Session and Chapter.	Title or Short Title.	Extent of Repeal
1 William and Mary, ch. 30.	An Act to repeal the statute made in the fifth year of King Henry IV. against multiplying gold and silver.	The Whole Act
5 William and Mary, ch. 6.	An Act to prevent disputes and controversies concerning Royal Mines.	The Whole Act
55 George III., ch. 134	An Act for altering the rate at which the Crown may exercise its right of pre-emption of Ore in which there is lead.	The Whole Act
1 James I. of Scotland, ch. 12.	Mines of Gold and Silver pertains to the King.	The Whole Act
12 James VI. of Scotland, ch. 31.	Anent the Tenth Part of Mynis.	The Whole Act

Department of Agriculture, Bombay

FODDER CROPS OF WESTERN INDIA

BY

HAROLD H. MANN, D.Sc.,

Ag. Director of Agriculture, Bombay Presidency, Poona.

~~**BULLETIN No. 100 OF 1920**~~
(Bulletin No. 77 of 1916, revised and enlarged.)
The crops mentioned in this bulletin have been
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MRS. RADHABAI ATMARAM SAGOON, Bookseller, etc., Bombay.
RAMCHANDRA GOVIND & SON, Booksellers, etc., Bombay.
BOMBAY TRACT & BOOK SOCIETY, Bombay.
N. B. MATHUR, N. K. H. Press, Allahabad.
MANAGER, NYAYASHRAYA PRESS, Poona.
RAMA KRISHNA & SONS, Lahore.
SUNDAR PANDURANG (RAMNATH SUNDER, the Successor),
Bombay.
THE PROPRIETOR OF THE NEW KITABKHANA, Poona.
KARSANDAS NARANDAS & SONS, Surat.
N. M. TRIPATHI & Co., Booksellers, etc., Bombay.
MUNSHI SEETA RAM, Managing Proprietors, Indian Army Book
Depot, Tuhi, Cawnpore.
MANGALDAS HARKISONDAS, Bookseller, etc., Surat.
KING & Co., Bombay.

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. On the other hand, it is beginning to be recognised that an animal is expected to do more than live, that if it is expected to work or to produce milk, better can be picked up during a large part of the year over the bare fields and stony hills of the Deccan and corresponding places in other parts of Western India, or that can be furnished by rice straw or a limited amount of *jow kadbi*, must be provided. An interest in the purely fodder crops is therefore rising.

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

Area under fodder crops in the various districts of the Bombay Presidency (excluding Sind) in 1907-08 and 1908-09.

1907-08
1908-09

Acres
26,4

Area under fodder crops (Bombay Presidency excluding Sind).

	Acres.
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

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

IN SIND the area is remarkably small considering the fertility of the country and the facilities for irrigation. The following are the figures of area during the last few years :—

	Acres.
THE SINDH AGRICULTURAL SOCIETY, Thar and Parkar.	.. 12,553
B. RAMJI	.. 13,678
Mrs. R. RAMJI	.. 10,726
BOMBAY N. B. M. MANAGER,	.. 8,409
RAMA KRISHN	.. 9,166
SUNDAR PANTH	.. 11,232
Bombay. THE PROPRIETOR,	.. 13,266
KARSANDAS NA	.. 16,127
N. M. TRIPATHI	.. 9,693
MUNSHI SEETAJI	.. 37,568
Depot, Tuhi, Cambay.	.. 17,847
MANGALDAS H. KING & Co., Bombay.	.. 12,479
1917-18	..

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

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

II.—The Features of a Good Fodder Crop.

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

to a farmer as a special fodder crop, to which he is expected to devote any considerable portion of his land.

These characters are as follows:—

1. The crops must be palatable, digestible and not injurious to the animals which are expected to eat them. The palatability is generally connected with a leafy character, and with succulence of stems and leaves. A large amount of fibre means a less satisfactory fodder,—and hence one has to consider very closely the stage at which a crop should be harvested if it is designed as a fodder crop. Many, among the most usual fodder crops, rapidly increase their content of fibre after a certain stage in their growth, and what was a good fodder before becomes a very inferior one later. Many grasses may be cited as examples. When they flower they are excellent: when they ripen they are barely worth the cost of harvesting. Rice straw is, after the rice has been reaped, an exceedingly poor fodder,—so is wheat straw. And yet in earlier stages these are excellent feed.

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

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

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

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

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

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

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

A good fodder crop then—

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

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

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

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

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

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

III.—Jowar or Sorghum.

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

Climate required for Jowar.

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

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

District.	Talukas.	Average Rainfall.	Percentage of total cultivated area under <i>jowar</i> .	Percentage of cereal acreage under <i>jowar</i> .
		Inches.		
Poona	Haveli ..	31·9 (Poona) ..	14·1	28·9
	Sirur ..	21·7 ..	25·9	39·1
	Bhimthadi ..	23·3 ..	39·8	60·5
	Mawal ..	42·5 to 186·6 ..	3·4	9·1
Sholapur	(The whole district) ..	22 to 26 ..	39·5	69·5
East Khandesh	(The whole district) ..	23 to 31 ..	18·0	51·3
Belgaum	Belgaum ..	51·9 (Belgaum)' ..	7·4	17·2
	Khanapur ..	71·1 (Khanapur) ..	2·3	4·0
	Athni ..	23·0 ..	29·8	56·6
	Parasgad ..	23·2 (Saundatti) ..	30·6	53·3
Ratnagiri	(The whole district) ..	80 to 165 ..	Nil.	Nil.
Kolaba	(The whole district) ..	88 to 135 ..	Nil.	Nil.

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

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

Jowar is essentially a crop of semi-arid tropical and sub-tropical regions, and is particularly valuable as a fodder crop in such areas,—as it is unaffected by the very dry atmospheric conditions which usually prevail, and it needs a minimum amount of soil moisture. This is illustrated by the fact that it requires less water per pound of dry matter produced than

* 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	..507 lbs.
Oats	..604 „
Barley	..513 „
Maize	..369 „
<i>Jowar (Sorghum)</i>	..306 „

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

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

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

Varieties of jowar.

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

* 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).

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.

* 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

* Mollison—Poona Farm Report, 1893-94.

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

‡ *Pennisetum typhordeum*.

§ *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 Bombay Presidency, as a *kharif* crop it appears to thrive on almost any description of fairly good soil, with a moderate well distributed rainfall. It grows excellently on medium black soil but in the Deccan only does moderately as an irrigated crop either in the cold or hot seasons.* ” In the south of the Bombay Presidency it can probably be replaced advantageously by one of the other fodder *jowars*.

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

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

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

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

* Nadiad Farm Report, 1912-13,

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

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

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

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

* 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 nineties by Mollison, and grown on a medium black soil with fair drainage. The yields obtained at the Poona farm in the years since 1893 are summarised below. I have re-calculated all the yields given to a basis of dry fodder, counting one pound of dry fodder as produced

* Surat Experimental Farm Report, 1913-14,

by $2\frac{1}{4}$ pounds of green fodder. The first series concerns the production of fodder as a rains crop without irrigation. The crop was usually sown about the last week of June or the beginning of July, and reaped from the beginning to the middle of September when in flower.

Year.	Yield of dry fodder.	Cost of production.		Value of crop on sale.		Remarks.
		Rs	a p.	Rs	a. p.	
1893	8,320 pounds	44	0 0	75	0 0	After lucerne which failed.
1894	11,896 do.	16	0 0	107	0 0	
1895	8,960 do.	16	0 0	69	0 0	
1896	11,700 do.	24	0 0	91	0 0	
1901	3,846 do.	20	0 0	30	0 0	Spoilt by continuous rain in July.
1902	4,910 do.	46	0 0	38	0 0		Spoilt by heavy rain in September.
1903	6,058 do.	29	0 0	45	0 0	
1905	6,960 do.	35	0 0	52	0 0	
1910	8,436 do.	45	0 0			
1911	13,464 do.	43	0 0			

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 $4\frac{1}{4}$ 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†.

* Poona Farm Report, 1896.

† 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 times.	3 cuttings, 43, 89 and 153 days.	lbs. 12,756
August 22nd	.. Do.	2 cuttings, 50 and 122 days.	7,768
September 9th	.. Irrigated seven times.	2 cuttings, 62 and 146 days.	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* :—

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

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

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

† Dharwar Experimental Farm 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.

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

Experience in the Deccan.—Inasmuch as Gujarat is already supplied with very excellent fodder *jowars* in *sundhia* and *dudhia* practically all our experience with other varieties has

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

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

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

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

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

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

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

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

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

* Mollison—Poona Farm Report, 1897.

† Poona Farm Report, 1895.

‡ Poona Agricultural College Farm Report, 1912-13.

§ Manjri Farm Report, 1904.

¶ 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.

* 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 soil and will better resist drought. On the other hand it matures more slowly than *sundhia* and the fodder is at least twenty per cent. less valuable in popular opinion. It is not the best *jowar* for hot weather growing, and is not suitable for planting at least after August.

UTAVLI JOWAR.

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

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

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

* 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.	
<i>Utavli</i>	..	7,575
<i>Nilwa</i>	..	4,846
<i>Sundhia</i>	..	3,846

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

Year.				Yield of dry fodder.	Cost.	Value of produce.
				lbs.	Rs. 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.

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

Crop.	Date of sowing.	Date of flowering.	Number of days from sowing to flowering.
<i>Sundhia</i>	July 15th	September 5th	62
<i>Nilwa</i>	July 9th	September 19th	72
<i>Utavli</i>	July 10th	September 13th	65

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

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

1909-10.

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

1910-11.

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

In the Southern Maratha Country at Dharwar, as a rains crop, it yielded better than *sundhia* or *nilwa*, grew quicker than the latter, and reached a height of over six feet. The green crop obtained was 18,048 pounds of green fodder (equal to 8,000 pounds of dry fodder) per acre, but this was

considerably inferior to the yield of fodder given by the local *jowar* "*Fulgar yellow*" when grown for this purpose.* A quick growing rains fodder does not seem to be specially needed at Dharwar, where the rains continue longer than in the Deccan.

HUNDI AND KALBONDI JOWARS.

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

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

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

Variety.	Date of sowing.	Date of cutting.	Yield of green fodder per acre.
<i>Hundi</i>	.. March 28th	1st crop—May 23rd to June 20th 2nd crop—July 14th to August 14th	lbs. 13,702 10,741
<i>Kalbondi</i>	.. April 10th	1st 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 dry fodder per acre.	Date of sowing.	Date of cutting.	Cost per acre.
	lbs.			Rs. a. p.
1903	(<i>Hundi</i>) 8,400	March 28th	May 23rd and July 14th	No record.
1904	.. .. 12,460	April 20th	July 10th	31 0 0
1905	.. .. 5,320	March 1st	July 10th	55 0 0
1910	.. .. 19,300	March	July	144 0 0
1912	.. .. 8,772	April	June	23 0 0

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

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

The outturn per acre does not compare with the heavy yields obtainable from the varieties cultivated in the rains or even in the hot weather. As an example of the yields obtained on well tilled and manured land, with such irrigation as is necessary given to keep the crop growing vigorously, in 1903 on the Poona Farm a crop gave a yield of 9,553 pounds of green, equal to 4,250 pounds of dry fodder per acre at a cost of Rs. 34.* Again in 1904, under similar conditions, sown on September 20th and cut on December 17th it gave 2,430 pounds of dry fodder per acre at a cost of Rs. 11.

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

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

* 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 special fodder crop ; it is usually allowed to ripen and produce seed, the straw (*kadbi*) forming an excellent dry fodder. But in a dry or famine year, *shalu jowar* cultivated for fodder only, 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 jowar* 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

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

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

On light land, which, as already stated, usually means in the Deccan a shallow soil with very porous subsoil, and in a normal season, they yield considerably better than *sundhia*,

and not quite as well as *nilwa*. The following are figures obtained in 1894 :—

Crops.	Yield of dry fodder per acre.	Value of crop per acre.
	lbs.	Rs. a. p.
<i>Sundhia</i>	4,912	38 0 0
<i>Nilwa</i>	9,109	61 0 0
American sorghums (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.†

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.‡

IMPHI JOWAR.

Imphi is an African sugar sorghum, nearly related to those just described from America, and yields nearly as satisfactorily as these latter. It has been grown ever since

*Poona Farm Report, 1895.

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

‡ Private communication from Rao Saheb C. K. Kelkar,

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

Year.	Yild of dry fodder per acre.	Value of crop per acre.		Remarks.
	lbs.	Rs.	a. p.	
1894.	11,220	75	0 0	Spoilt by continuous rain in July.
1900	4,305	29	0 0	
1901	8,552	57	0 0	
1902	15,196	71	0 0	
1903	11,720	88	0 0	

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

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

SOUTHERN MARATHA COUNTRY JOWARS.

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

† 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.

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

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

(1) In Northern Gujarat on alluvial soil, *sundhia* is an ideal fodder crop for the rains and for the hot weather. It is not suitable for sowing after the end of August, when some type of *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 sixty-five days. As a rains crop, in ordinary seasons at Poona, it will give five tons or a little less of dry fodder per acre, thus being a little better than *sundhia* in point of yield and consequently inferior to *nilwa*. The fodder is only equal to *nilwa* in value. Its peculiar value is that it yields heavily when planted in August, when irrigation has to be used. It is not suitable for hot weather irrigation.

(f) *Hundi* and *kālbondi* give coarse fodder, and grow even more slowly than *nilwa* coming to flower in eighty days. They are not suitable for growing in the rains,

but are the best for the hot weather under irrigation, yielding on the average about five tons of dry fodder per acre on good well tilled and well manured land.

(g) *Shalu jowars*, of various kinds, are the only ones suitable for cold weather growing, after September, under irrigation. They yield, however, much less fodder than those previously indicated, not usually much more than two tons of dry fodder per acre on good well tilled and well cultivated land.

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

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

Cultivation.

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

it is sown thickly the stalks will grow tall and thin, and produce small heads of grain."*

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

Nilwa jowar 1893 (Rains crop)—

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

Nilwa jowar 1895 (Rains crop)—

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

Sundhia jowar 1895 (Rains crop)—

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

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

<i>Sundhia</i>	..50 to 60 lbs. per acre.
<i>Nilwa</i>	..40 to 45 „
<i>Utavli</i>	..40 to 45 „
American Sorghums and	
<i>Impbi</i>	..50 lbs. per acre.
<i>Hundi</i> and <i>kālbondi</i>	..40 „
<i>Shalu</i> should have the same rate as <i>hundi</i> and <i>kālbondi</i> .	

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

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

Very large yields can be produced by the use of sewage or sewage effluent. On the Poona Experimental Farm in

1899-1900, the following outturns of various *jowar* fodders were obtained :—

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

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

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

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

* See Kelkar—Night soil, a valuable manure. Bulletin No. 34 (1909), Bombay Agricultural Department.

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

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

A hot weather crop needs regular irrigation, and irrigation is required every eight or ten days in the Deccan or every four

or five days on the light soils of Northern Gujarat. The first watering should be given immediately after sowing, and the second and third after an interval of four days. The soil between the rows should be loosened by bullock hoeing two or three times before the crop is six weeks old.

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

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

In growing a mixed crop, either in the rains or in the rabi season the pulses which have proved successful with the *jowar* are *kulthi* (*Dolichos biflorus*) on light soil in the rains, and *mug* or *udid* (*Phaseolus mungo*), *chavli* or cowpea (*Vigna catieng*) 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

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

proportion of seven parts of sorghum and one part of pulse seed :—

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

In Pennsylvania the average yield of a mixture of sorghum* 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.

* Pennsylvania 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.

* 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.

Poisonous character of young jowar plants.

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

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

- (1) The *jowar* fodder is usually dangerous till the flowering stage.
- (2) The dried fodder is much less dangerous than the green fodder even if it is dangerous at all.
- (3) The *rabi* varieties are much more dangerous than the rains varieties.
- (4) *Shalu* jowars generally are the worst.
- (5) The most dangerous of all is a crop which has grown vigorously and luxuriantly and then been checked and stunted by drought or disease.

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

“ There is some danger of poisoning the animals fed on any species of sorghum (*i.e., jowar*) which has been cut when only a few feet high after a long break in the monsoon. Animals which have been fed on the poisonous plants die very soon with symptoms resembling tympanitis : in some cases animals have died within twenty minutes of eating the fodder. An instance occurred on the Allahabad farm when sheep which were hired for the purpose of stock manuring,

were at the request of the owner turned out to graze an aftermath crop of *sorghum vulgare*. Eight of the sheep died within a few minutes, and many more were saved merely by the rapid administration of purgatives. During lengthy breaks in the monsoon, when the sorghum thus becomes poisonousthere 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.†

The cause of this was for long unknown. It was attributed to various causes, including the presence of nitrate of potash in the plant*. It was, however, shown by Dunstan and Henry‡ 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 :—

*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† (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,‡ 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

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

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

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

§ Nebraska Station Report, 1909.

¶ 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;

* 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 ;

(5) that the ratoon crop is much relished by cattle, but when young is more poisonous than the original crop*.

Utilisation of Jowar Fodder.

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

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

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

(2) *Making into hay.*—The question of making hay from *jowar* fodder does not usually arise in connection with the crop grown during the hot weather, which is grown for immediate use. The crop grown during the rains is likewise not

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

† Farm Manual.

produced at such a time of the year as is favourable to the production of hay. Over nearly all the districts of Western India, the crop sown in June or July is ready for cutting while the weather is still extremely uncertain, and efforts in Poona to convert the plants into hay have not been very satisfactory. The crop, if made into hay, should be made perfectly dry,* otherwise it will turn black in the stack and go mouldy.

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

"After mowing, allow the sorghum to lie upon the ground sufficiently long to dry out at the ends of the blades. If the crop is thick, it should be turned 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 be five feet high and four in diameter, of the shape of an old-fashioned beehive. All of the hay that is put up in this manner should be well settled as it is laid on the pile. After having constructed it to the proper height, rake the loose sorghum away from the sides, leaving a neat pile of hay that will turn water in case it should rain. Allow it to remain in this shape for two or three days for fermentation to take place, which is evidenced

* Farm Manual.

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

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

by the 'heating' and the deposit of dew upon the interior parts of the cock. When thoroughly warm and before the hay loses its natural colour, open the cocks and expose the hay to four or six hours' sun, according to the weight of the crop per acre and the size of stacks; then the hay is ready to haul to the barn or be placed in stacks, where it may safely be expected to remain without moulding or heating further. If the hay is allowed to remain in the cocks too long, the fermentation proceeds too far and the hay sours and then rots in the field. It will remain longer in the cocks without damage the less of water or sap it contains when put up..... Use no salt or other applications to preserve the hay. The hay may be baled safely if given six to ten hours sun from the cock, depending on the size of stalks."

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

* Farm Manual.

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

‡ 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 fermented, 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*

* C. V. Piper *Forage crops and their culture*, 1914.

† *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† 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

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

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

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 (12½ *pukka* seers). Stir up the liquid with a stick until all is dissolved. The solution is now ready for use.

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

* Leaflet No. 20 of 1909.

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

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

Jowar Borer.—The most important and widely distributed of these insect pests is the *jowar* borer—a caterpillar 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

*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 pulled up at once and fed to cattle without delay. This will partially prevent the production of the larger second and third broods.

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

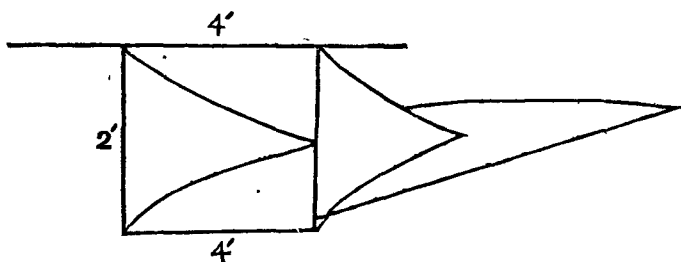
Jowar Grasshopper.—Nearly all the locusts and grasshoppers will attack jowar, and in all the districts where locusts are found there are records of serious damage being done by them. But one of the wingless grasshoppers (*Colemannia sphenarioides*) has been in certain seasons a veritable pest doing very 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 :—

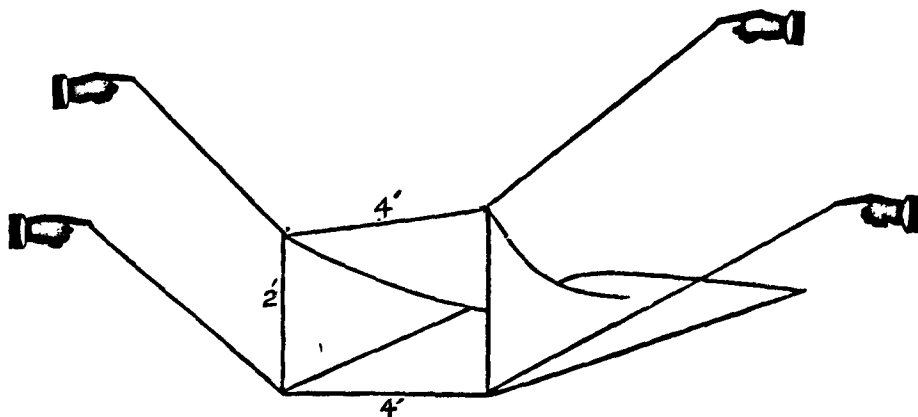


No. 1. BAG FOR CATCHING HOPPERS.

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.

It is very useful in grass lands, and in young or low crops. In an experiment, by the use of three of these bags for seven hours, no less than 14 lakhs of insects were captured, weighing 80 seers.

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



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

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

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

Feeding Value of Jowar Fodder.

I have examined many samples of fodder from *jowar* plants, both green and dry. All of them contain between

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

	Sun- dhia.	Ameri- can sorg- hum.	Nilwa.	Hundi.	Utavli.	Shalu.
	p. c.	p. c.	p. c.	p. c.	p. c.	p. c.
Water	60·0	60·0	60·0	60·0	60·0	60·10
Ether Extract (oil, etc.)	0·6	0·6	0·6	0·6	0·6	0·6
*Albuminoids (i.e., nitrogen × 6½)	2·0	1·3	1·5	2·3	1·4	1·8
Digestible carbohydrates	21·9	20·1	20·3	23·5	20·5	21·6
Woody fibre	12·5	14·9	14·6	11·1	14·3	12·9
Ash	3·0	3·1	3·0	2·5	3·2	3·1
	100·0	100·0	100·0	100·0	100·0	100·0
*Containing nitrogen	0·32	0·20	0·24	0·34	0·22	0·28

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

	Uta- vali.	Nilwa.	Khon- di.
	p. c.	p. c.	p. c.
Water	10·0	10·0	10·0
Ether Extract (oil, etc.)	1·8	1·5	1·2
†Albuminoids (i.e., nitrogen × 6½)	6·4	5·7	5·9
Digestible carbohydrates	41·9	41·6	43·5
Woody fibre	33·4	32·8	32·8
Ash	6·5	8·4	6·6
	100·0	100·0	100·0
†Containing nitrogen	1·0	0·9	0·9

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

	Amber sorghum in bloom *	Amber sorghum seed forming (milk stage)*	Average of 31 analyses. †
Water	p. c. 10·0	p. c. 10·0	p. c. 10·0
Ether Extract (oil, etc.)	.. 5·3	.. 4·5	.. 5·4
‡Aluminoids (i.e., nitrogen × 6½)	.. 6·2	.. 4·9	.. 4·8
Digestible carbohydrates	.. 41·1	.. 49·7	.. 49·9
Woody fibre	.. 32·3	.. 26·3	.. 24·5
Ash	.. 5·1	.. 4·6	.. 5·4
	100·0	100·0	100·0
‡Containing nitrogen	.. 1·0	.. 0·8	.. 0·8

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

	Dried jowar plants (heads just appearing). ‡	Dried jowar plants (seeds just forming). ‡
Moisture	p. c. 10·0	p. c. 10·0
Ether Extract (oil, etc.)	.. 3·1	.. 1·9
¶Aluminoids (i.e., nitrogen × 6½)	.. 9·0	.. 6·4
Digestible carbohydrates	.. 36·0	.. 42·3
Woody fibre	.. 31·8	.. 30·4
Ash	.. 10·1	.. 9·0
	100·0	100·0
¶Containing nitrogen	.. 1·44	.. 1·02

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

‡ Farmers' Bulletin, U.S.A., No. 50.

‡ Thatcher—Report of Nebraska Agricultural Experiment Station, 1900.

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

IV.—Maize.

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

Climate Required for Maize.

The country where maize growing has developed to a greater extent than anywhere else in the world, both for grain and for fodder, is the United States of America. There, it is the premier crop of the country, and dominates the agriculture of a vast area of land extending from semi-tropical conditions to those with a very hot summer and a very cold winter. Of course there are an almost endless number of varieties suited to these varying conditions, some ripening quickly, some slowly, some yielding grain and little fodder,

some much fodder and relatively little grain. But the general result of a consideration of its range in the United States shows that maize is one of the most tolerant of crops so far as climatic conditions are concerned, more especially when it is grown for fodder. It will not stand frost, and does not grow rapidly below about 60°F. but so far as temperature is concerned it will do well wherever the mean is above this point (60°F.) during the growing period. As to rainfall, it does not seem to flourish where there is a combination of high temperature and heavy rainfall so far as giving a high yield is concerned. Most of the best part of the great maize area in America has a rainfall ranging from 30 to 40 inches per annum. But provided it has not to stand waterlogged conditions, maize is capable of growing for the production of fodder under very widely different conditions of rainfall.

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

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,

* 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 2½ pounds of green fodder.

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

These figures give an average yield of 9,700 pounds or about 4½ tons of dry fodder per acre on well-manured land. This is just about equal to the yield of *sundhia jowar* under similar conditions. It is fully understood that this is only obtained on well manured land; the yield rapidly falls off if the manure is omitted.

* 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.	Yield of dry fodder per acre.	Cost of production.		Value of crop.		Remarks.
		Rs.	a. p.	Rs.	a. p.	
1904	8,700	48	0 0	65	0 0	February to May. Do.
1908	11,200	151	0 0			
1910	10,700	152	0 0			
		<i>Autumn and cold weather.</i>				
1905	4,500	17	0 0			Following manured maize and sown on September, 29. December to February. Do.
1909	8,300	43	0 0			
1911	5,980	30	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 November ..	7,031 ..
3rd Crop	December to February ..	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† 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.

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

‡ 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.† It will usually pay to apply eight to ten tons per acre of cattle manure. It is rarely advisable or necessary to use concentrated artificial manures, but (as above indicated) four good crops in succession have been obtained after treatment with two thousand pounds of safflower cake per acre. The crop, further, grows excellently on sewage effluent‡. The crop is not usually intercultured, if the soil has been well prepared, but

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

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

‡ 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 completely.

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

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

* 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 the maize stalks in the field†.

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

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

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

Utilisation.—In Western India the fodder maize crop, in the few cases when it is grown, is usually cut in the field and fed green to stock direct. When grown in the hot weather,

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

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

§ 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 sugary."† It will hardly, however, fetch as high a price as *sundhia* 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.‡

		Percentage digested.			
		Proteids.	Fat.	Nitrogen— free extract.	Fibre.
Immature fodder	..	47·4	45·9	57·6	67·9
Fodder at dough stage.	..	36·0	66·1	60·6	56·7

This would indicate that as the crop becomes 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.

* See Poona Farm Report, 1893.

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

‡ 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 America, it is often regarded as useless, and is left standing in the fields or burnt. In India Meagher and Williams* state that it "makes an inferior fodder when fed after the cobs have ripened, and should be fed only to working cattle when mixed with other fodder." The fact that maize fodder so largely loses its value if left till the grain is mature should never be forgotten. In case maize is grown for seed it is a common practice in India to strip the leaves for fodder during growth, as this is said also to improve the seed.

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

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

* Farm Manual.

† See *Crisdale-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 can be put in the silo without chaffing, but it means a larger loss from the material becoming mouldy. The better the material is cut up the better, and some authorities even recommend cutting it into half-inch lengths.

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

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

Diseases and Pests of Maize.

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

Maize Borer.—The only really serious pest is the moth borer, which under the name of the “*jowar borer*” has already been described when considering the *jowar* crop.

* 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.”

† 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 be removed, and burnt or otherwise utilized as soon after the removal of the crop as possible.

Maize Fly (Delphax psylloides)—This small dark insect, not unlike a large aphid, is found in the sheathing leaves of maize. "The insects are active, running crab-like with a sideways 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 importance in Western India.

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

Feeding Value of Maize Fodder.

Maize when cut at the stage suggested, usually contains between 70 and 80 per cent. of water, and most often over 75 per cent. There is a tendency, judging from the published analyses, for maize fodder to be more watery in colder climates than it is in Western India. Thus for instance in England it contained, as the average of numerous analyses, 83·2 per cent. of water, the amount being greater in bad seasons than in good ones. At the same time large well-grown, advanced

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

It will be seen that, calculated on a similar basis of water the composition of this maize fodder is not widely different from 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.‡

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

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

† Feruglio and Mayer, 1909.

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

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.
	p. c.	p. c.
Water	75·0	75·0
Ether Extract (oil, &c) ..	0·8	0·7
†Albuminoids (i.e., nitro- gen x 6¼)	2·3	2·8
Digestible carbohydrates ..	11·3	10·4
Woody fibre	8·0	9·3
Ash	2·6	1·8
	<hr/>	<hr/>
	100·0	100·0
†Containing nitrogen ..	·36	·45

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

Percentage of Constituents digested.

	Pro- teids.	Fat.	Nitro- gen.	Fibre.
(1) †Maize fodder	59·6	72·3	74·4	79·8
Maize silage	46·7	68·3	64·1	67·2
(2) ‡Maize fodder (green)	73·5	83·0	76·1	75·3
Maize silage	66·2	82·5	71·9	74·2

* Annett and Russell—*loc cit.*

† 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

* 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.

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

Under the conditions which it prefers, *bajri* will grow very quickly, and yield very heavily in fodder, giving in some cases more fodder than the *jowars* and producing it almost as quickly as the best of these. In 1896, grown thickly, it gave 10,300 pounds or over 4½ 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 the same year on light land it gave a yield

of 9,011 pounds per acre, or practically an equal yield to *nilwa* which produced 9,149 pounds per acre. These are the conditions which it prefers, and on which relatively the best results will always be obtained.

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

* Piper—Forage Plants, page 302.

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

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

§ Kenny—Rhodesia Agricultural Journal. Vol. VII (1910).

utilised when employed to grow grain and fodder than when used to produce fodder alone. If it is desired to grow *bajri* for fodder in places suitable to it, one of the Gujarat varieties (*malbandro* or *deshi*) should be employed and it had better be sown thickly as already recommended for fodder *jowar*, and grown only as a rains crop. It will need from fifteen to twenty pounds per acre of seed, and with favourable rains will be ready to be cut in full flower in from sixty-five to eighty days after sowing. A better method, probably of utilising the fodder is to cut before this stage, when the flower stalk is only appearing, and then take fresh cuttings as the plants grow up again. There is no danger of feeding the material cut at this stage, as would be the case with *jowar*.

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

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

	Per cent.
Water	60·0
Ether Extract (oil, &c.) ..	0·4
†Albuminoids (<i>i.e.</i> , nitrogen \times 6 $\frac{1}{4}$)..	1·3
Digestible Carbohydrates ..	20·0
Woody fibre	15·8
Ash	2·5
	<hr/> 100·0 <hr/>
†Containing nitrogen	0·21

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.*

*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:—

Date of sowing.	Yield of dry fodder.	Length of time growing.	Cost of crop.	Number of irrigations required.
1912 and 1913-14.	lbs.	days.	Rs. s. p.	
August 22†	1,840	55	23 0 0	None.
September 15†	2,880	53	52 0 0	5
October 15 or 16†	4,360	68	53 0 0	4 to 5.
November 1	5,120	74	54 12 0	4
November 15†	5,336	82	56 0 0	5 to 6.
December 1	5,920	75	61 0 0	4
December 15	3,720	87	56 8 0	5 to 6.
January 15†	4,400	70	56 0 0	6
February 15†	4,000	65	71 0 0	8
March 15†	5,600	53	50 0 0	5
April 15†	4,400	39	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 only.

‡ 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	..	..	60·0
Ether Extract (oil, etc.)	..	..	0·8
*Albuminoids	..	..	2·1
Digestible Carbohydrates	..	..	20·8
Woody fibre	..	..	12·2
Ash	..	..	4·0
			—————
			100·0
			—————

*Containing nitrogen 0·34

This shows a fairly high percentage of nitrogen.

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

The fodder derived from *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.

† Piper—Forage Plants.

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

* 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° and 71° F. and that below 64° F. the growth is delayed by from five to ten days. Heads are usually formed under the best conditions from thirty-five to forty days after sprouting.

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

Date of sowing.				Yield of dry fodder.	Length of time growing.	Cost of crop.	No. of irrigations required.
				lbs.	Days.	Rs. a. p.	
1912.							
October 15	..	..	..	2,672	53	34 0 0	3
November 1	..	..	..	2,240	51	44 0 0	3
November 15	..	..	..	3,440	63	55 8 0	5
December 1	..	..	..	2,848	75	51 0 0	5
December 15	..	..	..	3,600	91	48 8 0	3

* 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 grows much more quickly, requiring sixty-six days as against eighty-one in the other case. It is doubtful whether it ought to be recommended until all fear of frost is over.

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

OTHER MILLET CROPS.

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

Nachani (*nagli*, *ragi*, *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 too expensive for a fodder crop. For the latter purpose, it should be sown broadcast or in drills at the beginning of the rains, in light soil with fairly heavy rainfall.

It has been considered as making a good fodder for cattle and can be siloed or used as a green fodder when the seed is approaching maturity.* On the other hand, Mollison†

* Meagher and Williams—Farm Manual.

† 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

* Meagher and Williams—Farm Manual.

† Choula=chavli. See under the latter crop.

berseem should be ready."† These notes indicate the conditions under which it is likely to be of service, and its method of culture.

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

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

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

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

If we summarise the position as fodder crops which the various millets—*bajri*, *kang*, *cheno nachani*, *sawan*, etc.—are

† Henderson—Mirpurkhas Farm Report, 1909-10.

‡ 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

* Farm Manual.

aware of other data on the subject. I therefore quote the substance of their account.

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

evening be sufficiently dry for 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.

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

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† and also in the drier regions of Texas.‡ It seems as if it will go on growing as long as the temperature is sufficiently high, and sufficient moisture is provided. As Mollison remarks (*vide supra*) in the more temperate parts of India it ceases to yield in the cold weather, though the temperature never goes below 40° to 45° F. Even at Surat, with a minimum temperature five degrees higher, its cultivation was abandoned in 1906-07, as the yield outside

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

† Scott—Florida Agricultural Experiment Station Report, 1912.

‡ 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.† 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.¶

* Surat Agricultural Station Report, 1906-07.

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

‡ Ratnagiri Agricultural Station Report, 1913-14.

§ Mollison—*loc cit.*

¶ Meagher and Williams—Farm Manual.

*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.†

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

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

After a plantation has been established, "guinea grass can hardly get too much water or manure‡." The richer the land, the more succulent and tender will the fodder be.‡ Each year at least fifteen cartloads (12,000 pounds) of farmyard manure per acre should be applied before the

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

† Mollison—*loc. cit.*

‡ 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 farm-yard 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 oil-cake or dried blood. In an experiment in Florida, it was found that guinea grass manured with a mixture of nitrate of soda, superphosphate, and potash manure gave a yield of 3,370 pounds of cured dry hay per acre, while a similar plot manured with dried blood only gave 2,341 pounds similarly cured.†

If guinea grass be grown under sewage or sewage effluent very high and sometimes extraordinary yields may be obtained. At Poona, with septic tank effluent in 1899-1900, 56,308 pounds of green fodder per acre were grown 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.‡

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.

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

† Florida Agricultural Experiment Station Report, 1911.

‡ Kelkar—Bulletin No. 34 (1909), Bombay Agricultural Department.

§ 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.

* 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 (53½ tons) of green fodder per acre in twelve cuttings.* This is an extraordinary amount and far in excess of any other record I have seen except that quoted from Karachi. Thirty-two tons per acre have, however, been obtained in the Philippines, and this in four cuttings.† Under ordinary circumstances in India, however, it yields between thirty and forty thousand pounds of green fodder per acre as a maximum and the yield of a plantation even when renewed frequently tends to fall to half this amount. At Pusa‡ in 1911-12 the maximum yield quoted was 28,700 pounds per acre.

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

POONA.

Year.	Yield per acre.	Cost per acre.	Value of crop per acre.	Number of cuttings.
	lbs.	Rs.	Rs.	
1893	35,028	110§	233	10
1894	21,295	82	106	10
1896	19,167	49	96	No record.
1897	16,106	73§	80	"
1898	15,493	53	77	"
1899	13,552	67	68	"
1900	17,103	61	114	"
1902	13,662	60	91	"
1903	12,252	No record.	(Profit Rs. 46)	"
1904	12,551	49	84	4
1905	12,559	34	89	"
1906	15,566	42	78	"

* Farm Manual.

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

‡ Milligan—Report Imperial Agriculturists 1911-12.

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

These records of yield in Poona tell of the very large yields which may be obtained. They tell also how essential it is for a plantation to get full attention and to be fully renewed. In the present instance this renewal was not attended to, for in 1904 it was noted that "the plantation is old and needs renewal." The result was a decline in yield, and a reduction in the number of cuttings. During the years from 1893 to 1900 the average yield was 19,700 pounds or 8·8 tons of green fodder per acre—equivalent to slightly under four tons of dry fodder per acre. The average annual yield is thus a little below what would be expected for a single crop of *sundhia* fodder, though, of course, the crops cannot be compared purely on a basis of yield. In the following years (1902-1905) when the plantation was confessedly old and needed renewal, the average yield was only 12,750 or 5½ tons of green fodder, equivalent to 2½ tons of dry fodder per acre. The yield of an old plantation may go down as low as 4,100 pounds of green fodder per acre. The urgent necessity of the frequent renewal of a guinea grass plantation could not be better illustrated than by these figures, especially as they are confirmed by experience at Surat to be given later.

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

SURAT.

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

Year.				Yield per acre.	Cost per acre.	Value per acre.
				lbs.	Rs.	Rs.
1898-99	..	..	..	28,580	172	190
1899-1900	..	..	..	29,549	116	197

* Poona Dairy Farm Report, 1908-09.

Year.				Yield per acre.	Cost per acre's	Value per acre.
				Jbs.	Rs.	Rs.
1900-01	..	..	..	42,594	170	213
1901-02	.	..	..	22,802	No record	114
1902-03	.	..	..	29,341	175	147
1903-04	..	..	..	25,835	176	172
1904-05	..	..	..	13,972	167	93
1905-06	..	..	..	18,613	194	124
1906-07	..	..	..	13,484	113	90

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

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

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

On light sandy land at Gokak† it was equally successful, and gave six cuttings in the first year and the same number in the second. This took place in spite of the land being somewhat salt (*karal*), and the soil having to be mixed with nala-silt before it would grow any crop. At Ratnagiri‡, as already stated, where the rainfall is much heavier, it has been so far exceedingly luxuriant though it is

* Report, Dhulia Agricultural Station, 1912-13.

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

‡ 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.

	1 Fresh grass (Poona).	2 Fresh grass (Poona).	3 Dried grass (Aver- age).
	p. c.	p. c.	p. c.
Water	63·4	71·5	10·0
Ether Extract (oil, etc.)	0·8	1·0	2·6
||Albuminoids (Proteid nitrogen x 6½)	1·9	2·6	6·2
Soluble Carbohydrates, &c.	19·4	13·7	45·8
Fibre	8·8	5·7	20·1
Ash	5·7	5·3	15·4
Total ..	100·00	100·00	100·00
||Total nitrogen	0·41	·53	1·3
Proteid nitrogen	0·30	·42	1·0

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 depts. "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,

* Mollison—*loc. cit.*

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

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

and several crops of hay may easily be obtained if the grass is not needed as green fodder.

VIII.—Other Gramineous Fodder Crops.

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

TEOSINTE.

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

* Forage Plants, page 304.

the fact that it needs rich soils, that on soils of moderate fertility it does not yield as well as sorghum (*jowar*), and that the seed cost is high.

Experience elsewhere seems to indicate that it has ultimately only really proved successful in damp, warm regions of high humidity, and large rainfall. In the West Indies (Dominica)† it gave, for example, twelve tons of green fodder per acre, and is considered as suitable for poor sandy soil there. In the Philippines it has given as much as 27·67 tons of green fodder per acre in 141 days.‡ I have myself seen it yield very high returns of green fodder in the Assam Valley. But in drier climates, with less rainfall, even when irrigation is available, it has been a disappointment. In Rhodesia§ it is considered as "not satisfactory." In Arizona|| it is not a success in dry farming, and so on. Its water requirements, per pound of dry matter produced, are, however, only slightly higher than those of maize.¶

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

Year.	Yield dry fodder per acre. **	Cost per acre.			Value per acre††		
		Lbs.	Rs.	a. p.	Rs.	a. p.	
1893	9,444	54	0	0	85	0	0
1894	15,204	28	0	0	115	0	0
1895	6,690	18	0	0	37	0	0
1896	2,208	12	0	0	22	0	0††

† Dominica Botanical Station Report, 1908-09.

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

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

|| Arizona Agricultural Experiment Station Report, 1912.

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

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

†† Teosinte fodder at first commanded the same price on the market as *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

*Poona 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.[‡]

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

[†] Poona Agricultural College Farm Report, 1913-14.

[‡] Grown 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.†

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

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

† There has been a good deal of confusion about the name applied to this grass. In some Indian publications, and in some from the West Indies also, it is called "Sudan grass." Now this latter name is used in the United States (where the name was first used) for an annual grass which is very different in all its cultural characters, and with which I shall deal below (see page 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.

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

sowing, was realised,—and as the yield in the first year was very good, it seemed that it was likely to have a future in Western India. It was introduced into Poona from the military grass farm at Allahabad, was sown in July, and cut in August, yielding 4,720 pounds of green fodder per acre in one cut. It was noted as growing vigorously in the early monsoon in Poona. In the following year it grew well so long as the rain continued, but a drought in August and September completely stopped its growth,—while a plague of rats found the underground perennial stems a favourite food.

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

* 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.

† *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 reports have been made of injury from this cause. Duthie says that in Northern India various reports indicate its injurious effects on cattle if eaten when too young or when the plants are stunted by drought.†

* Forage Plants, page 245.

† Fodder Grasses of Northern India (1886).

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 very rich and succulent fodder. It was stated that "provided it can obtain enough moisture, it will grow anywhere", even on poor sandy land, and with fairly deep soils it was found to withstand a moderate amount of drought when well established as a perennial grass. The country where it is grown in New South Wales has not to undergo a really serious drought, such as we have in Western India every year, except occasionally. When Australian and other writers speak of a drought

resisting plant* it must not be taken that what they say would mean in any sense that the plant would be able to endure the seven or eight months 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.†

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 ever-green, being affected only by severe cold. Although its name suggests its growing in wet places, it flourishes in almost any kind of soil, and improves under grazing and trampling. It grows from seeds or root cuttings, and when established, it lasts indefinitely, while it is not difficult to control if a change of crop is desirable. Though it will stand a fair amount of drought when well-established on deep soils, it is perhaps more characterised by being able to stand much wet weather, as illustrated by its behaviour in Guam where it is stated to have done well on poorly drained soil during long periods of heavy rainfall.‡

This grass had been introduced into India between 1890 and 1900 and had given good results in Tirhut, under conditions of soil and climate quite likely to suit it if it once became well established. In the anxiety resulting from the terrible famine of 1899-1900, one of the most extensive and

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

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

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

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 then by the Government of India in the Agricultural Ledger.* As a result enquiries were made from all over the parts of India liable to be affected with drought, a considerable amount of the seed was purchased at a high price and imported from Australia, and experiments were initiated with it on experimental farms and elsewhere.

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

Our experience in Western India, where it has been grown experimentally at Poona‡ is what, perhaps, might have been expected. In 1902 when introduced it was found to grow well, to tiller splendidly, but to grow flat and not tall, and to suffer very much on the medium black soil of the Poona farm as soon as the long dry season became established. It was saved alive by irrigation, and it was hoped that the acclimatised seed might show better results than that originally imported. The next year the same result was repeated. The grass only survived by means of irrigation,

* Agricultural Ledger (1901) No. 1.

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

‡ 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

* Nadiad Farm Report, 1903.

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

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

Thus the average yield for eight years, in a position where most good grasses will not flourish, was over 30,000 pounds or nearly 13½ tons of green fodder per annum. In spite of this very excellent yield, the grass 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, † 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

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

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

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 cuttings, the grass being grazed after the second of these was taken. In Florida three or four cuttings are obtained annually, making in all from six to eight tons of hay, equal to 13 to 16 tons of green fodder per acre in each year. In dry places, on the other hand it is no use. In Texas where irrigation was not available, and where, though it rained every month, the annual rainfall was only 20 to 25 inches, it gave no growth and quickly died out.*

It grew well under irrigation, but was awkward to manage, owing to the thick mass of stems which quickly form on the

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

ground. With eight irrigations in the season, it gave over 4½ tons of green fodder per acre in Texas.*

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

Water	..	..	72·9
Ether Extract (oil, etc.)	..	..	0·2
Proteids (Nitrogen × 6¼)	..	..	1·4
Digestible Carbohydrates	..	..	13·8
Woody fibre	..	..	9·6
Ash	..	..	2·1
			100·00

It can be fed at any stage, and while with us it has been always used for cutting and feeding green, it has a very good reputation as a pasture grass. One authority says no other cultivated forage crop has been eaten with the same persistence and regularity in all stages of maturity as has this grass.‡ It is not injured by moderately heavy trampling or 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.

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

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

‡ Guam Agricultural Experiment Station Report, 1914.

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

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 —

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

† My account of Indian experience with this grass is almost entirely derived from notes 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 and in three or four centres of Western India is as follows :—

	Bangalore.	Poona.	Ahmedna- gar.	Belgaum.	Ahmeda- bad.
	ins.	ins.	ins.	ins.	ins.
January	0·2	0·1	0·1	0·1	0·1
February	0·1	..	0·1	..	0·1
March	0·6	0·1	0·1	0·4	..
April	1·3	0·7	0·3	1·7	..
May	5·0	1·4	0·8	2·6	0·3
June	3·2	5·2	4·6	8·4	3·8
July	4·0	7·6	3·2	15·7	12·5
August	5·9	31·7	3·0	8·9	7·6
September	6·3	5·0	7·0	4·8	4·3
October	6·4	4·3	2·9	5·0	0·4
November	1·9	0·9	0·8	1·4	0·4
December	1·7	0·3	0·6	0·3	..
Total	35·6	29·3	23·5	49·3	29·1

Whether Rhodes grass is likely to be suitable as an un-irrigated 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 moot question even in Bangalore, but apart from this and the possibility of frost in the more northerly parts of the Bombay Presidency, there seems considerable prospect of its being a very valuable addition to our fodder resources, filling a place similar to that occupied by guinea grass, and that might be also taken by para or Mauritius water grass.

* 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."* In the West Indies it is considered as a grass to improve poor animals† 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‡ and at a stage when suitable for cutting is shown in the following analyses, the grass being air dried before analysis. The first two are samples from Hawaii,§ the third is a sample from Bangalore done in my laboratory.

	Hawaii Samples.		Ban-galore Sample.
	p. c.	p. c.	p. c.
Water	11.7	9.8	5.4
Ether Extract (i.e., fat, etc.) ..	2.3	1.4	1.0
Proteids	6.1	7.3	3.5
Digestible Carbohydrates	42.5	44.7	44.9
Woody fibre	30.2	29.2	37.7
Ash	7.2	7.6	7.5
	100.00	100.00	100.00

The Bangalore sample is thus distinctly the most fibrous.

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

* Home and Draper—*loc cit.*

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

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

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

¶ Hungerford—Philippine 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 possibly fill with us. Experiment can only decide how far such anticipations are justified.

RED TEFF GRASS.

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

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

As a result no further experiments with this grass were done for many years. Interest in it has recently revived, and

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

† Collar—Saharanpur Garden Report, 1888.

‡ 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 widely from that of some of the places named, it would possibly also do well in the area of which we are treating. During the last 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. In the following year, sown in November, it yielded 14,360 pounds of green fodder per acre with six waterings and three cuttings, the bulk of the yield being given by the first cutting in March. Sown in March it was again a failure, it gave no cutting before the rains, and a very little after; sown in July it yielded so little as to be unworthy of consideration.

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

Those experiments would seem to indicate that in the United Provinces if teff grass is used it is only likely to succeed

* 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 analysis:—*

	South Africa.		Cawn- pore.
	(1)	(2)	
Moisture	Per cent. 8.88	Per cent. 9.16	Per cent. 6.95
Ether Extract (oil, etc.)	1.21	1.07	2.01

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

STATEMENT—*continued.*

	South Africa		Cawnpore.
	(1)	(2)	
Proteids	Per cent 6.21	Per cent 4.72	Per cent 4.06
Digestible Carbohydrates	39.08	42.71	51.45
Woody fibre	39.07	35.63	29.35
Ash	5.35	6.71	6.20
	100.00	100.00	100.00

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

SUDAN GRASS.*

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

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

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

Sudan grass gives a large crop of hay in a short time, and hence would replace several of the millets for this purpose, and some of the quick growing fodder *jowars*. It gives, however, better hay than the millets, and is cured with equal ease. It can be cut twice, thrice or even four times under conditions similar to ours, if the soil moisture is sufficient or

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

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

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

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

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

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

This crop is said to show remarkable resistance to drought and frost, but responds readily to irrigation. If water is liable at any time to lie, it is not suitable; and under these conditions, in South Africa it is considered that it can best

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

† 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 cutting of 1912 in February, and then gave crops on March 30, May 30, and June 30.* At the first and second cuttings it was four feet high, and the third and fourth it was 2½ feet high. This was in a year when there was no rain after the end of April, and the total rainfall was 21 inches. In 1913 it was cut twice when the plants were from six to seven feet high, with no sign of flowering. At each cutting from twelve to fifteen tons of green fodder per acre were produced. 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 carbohydrates ..	.. 17·29
Woody fibre ..	.. 14·77
Ash ..	.. 2·92
	100·00

* 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 grasses. It is highly relished by cattle, who will sort it out of a mixture and eat it first. As a green succulent fodder it is stated to give good results in milk production, and though, hitherto usually either grazed or fed green, it makes good hay. It gets very coarse after flowering, and so for hay making should not be cut at a later stage than this.

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

1912	8,200 lbs. green fodder.
1913	119,200 „ do.
1914	8,400 „ green fodder and 3,200 lbs. dry fodder.

Under ordinary dry cultivation in good land in good conditions in Poona, it keeps green till December and then turns brown. In April and May it is quite dry but grows

* 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 following results :—

	Before flower- ing.	In flower.	In seed.
	Per cent.	Per cent.	Per cent.
Moisture	69.9	65.9	65.4
Ether extract (oil, etc.)	1.6	1.7	1.7
Proteids (nitrogen x 6.25)	2.1	2.2	2.0
Digestible carbohydrates	13.5	14.9	12.8
Woody fibre	9.2	11.6	14.3
Ash	3.7	3.7	3.8
	100.0	100.0	100.0

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

* 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 lucerne. 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.

* De Candolle.

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

As far as cold is concerned, different varieties of lucerne differ very much in their capacity for frost resistance. There is no part of the Bombay Presidency, except Sind—where the crop can be hardly recommended, —where the frost received is serious enough to damage a stand of any varieties 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.† Certain varieties are so cold resistant that they are grown in the northern parts of Siberia (Yakutsk).

* Report, Mirpurkhas Agricultural Station, 1913-14.

† 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 yield more quickly and a greater crop for the money expended than lucerne supplies in the one season. Under certain of our conditions berseem supplies such a crop, and there are others. How far these will supply such a crop in the Konkan will be discussed later. In 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.

In 1906-07 Turkestan lucerne was imported from America as a drought resisting variety, and was planted at Dharwar and Dhulia. At the former place* it germinated well and flourished during the rains. After the rains were over it quickly began to suffer. In cuttings during the rains about 2,200 pounds of green fodder per acre were obtained. Leaf blight then appeared. After it was evident that it would die without it, irrigation was tried, and the plot was manured with farmyard manure. But all was in vain and the plots had to be ploughed up at the end of December. This applies, to an almost equal extent, to four strains of Turkestan lucerne. In Dhulia,† the same four strains as were tried at 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,‡ where lucerne is regularly grown, in 1909-10, grew very well, at first giving a fair return in the

* Report, Dharwar Agricultural Station, 1906-07.

† Report, Dhulia Agricultural Station, 1906-07.

‡ 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.†

There are said to be three varieties usually grown in India‡—the Kandahar or Quetta, the Persian, and the Meerut. I know nothing of the third, and those cultivated in Western India are the first two of these. The essential difference between them is that the first has a trailing habit of growth, while the second is upright. Under most circumstances the latter—Persian or Arabian—is 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,

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

† Dharwar Agricultural Station Report 1918-19.

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

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

* Mollison—Text Book of Indian Agriculture, Vo. III, 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 dying. The presence of a little salt was also considered to increase the drought resistance. It was found by Hilgard to tolerate much more sulphate than chloride or carbonate, being very sensitive to both these latter.‡ But on the whole lucerne is better avoided where there is any considerable amount of salt in the soil. Acid in the soil, even in very small proportion, is fatal,—and should be rectified by liming the land. It practically never occurs, however, in Western India.

* Coburn—The Book of Alfalfa, page 44.

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

‡ Hilgard—Soils, pp. 467 and 472.

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.†

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

The lucerne planted in August germinated well, but did not thrive, and gradually died. That put in in other months did well except that in February and later. From the February lucerne only two small cuttings were obtained and

* Poona Experimental Farm Report, 1893.

† 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 Cultivation.

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

* Mollison—*loc. cit.*

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 :—

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

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

“ Some farmers do not manure the land before sowing *bajri*. After the *bajri* harvest, the land is ploughed and *wafas* are made. Seed is broadcasted and then it is covered with,

* 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 thoroughly with the soil. Ridges are then formed. The seed is sown on the ridges which can be made 22 to 28 inches apart by an ordinary native plough. In practice it was found necessary to fashion the ridges afterwards into neat proportions with the hand hoe. The slope of the surface of the field will indicate the direction

* Mollison—*loc. cit.*

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* :—

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

* 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.”† In this case the difference was much greater than in other places : the yields in the first and second years were as follows :—‡

		<i>Yield per acre.</i>	
		1st year.	2nd year
		lbs.	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.

* Manjri Agricultural Station Report, 1910-11.

† Surat Agricultural Station Report, 1907-08.

‡ 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 eighteen 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.*
	Rs. a. p.	lbs.
I. Farmyard manure (15 tons before planting) (7 tons after every second cutting)	.. 133 0 0	26,860
II. Castor cake (7½ cwt. before planting) (3 cwt. after every second cutting)	.. 143 0 0	29,824
III. Crushed Bones (10 cwt. before planting) (4 cwt. after every second cutting)	.. 150 0 0	27,088

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

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

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.	Cost of additional manure.	Average yield.	Increased yield over plot I.	Value of increased yield.
	Rs. a. p.	lbs.	lbs.	Rs. a. p.
I. Nil	Nil.	18,711	Nil.	Nil.
II. Eleven cartloads farmyard manure extra ..	13 8 0	25,755	7,044	48 0 0
III. Sulphate of potash 167 lbs. Sulphate of ammonia 15 lbs. ..	13 8 0	27,705	8,994	72 0 0
IV. Superphosphate 243 lbs. Sulphate of ammonia 15 lbs. ..	12 0 0	30,500	11,789	94 0 0
V. Sulphate of potash 167 lbs. Superphosphate 243 lbs. Sulphate of ammonia 15 lbs. ..	24 0 0	29,578	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

* Knight and Patil—Agricultural College Farm Reports, 1912-13, 1913-14, 1914-15. Also summarized by Mann and Paranjpye 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, about 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.	Cost.	Value of crop.
	lbs.	Rs. a. p.	Rs. a. p.
(1) Farmyard manure and canal water.	74,620	258 0 0	373 0 0
(2) Poudrette and canal water ..	96,180	332 0 0	461 0 0
(3) Septic tank effluent ..	1,02,088	174 0 0	510 0 0

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

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

These are still good crops, considerably above the average.*

It might be considered that sewage is an unsuitable application for a crop which is intended to be eaten in the raw condition by horses and cattle. So it would be, I think, if the crop were sown on the bed system, where the stems of the plant would be in contact with the sewage liquid itself. If the ridge and furrow method is used, I do not think serious objection can be taken to the employment of sewage to irrigate the crop, as then the liquid never touches any part of the plant which would normally be cut. The trailing Quetta variety of lucerne should, however, not be grown. Another safeguard in the present case is the fact that the material used is septic tank effluent and not raw sewage. Few people, nowadays, 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

* 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.

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

1892-93	27,000 lbs. to 36,700 lbs.	green fodder per acre.
1896-97	28,700 „	green fodder per acre.
1904-05	27,900 „ to 39,000 lbs.	green fodder per acre.
1910-11	32,400 „	green fodder per acre.
1912-13	52,800 „	„ „

These figures give an average at Poona for first year lucerne of little less than 36,000 pounds of green fodder per acre.

At other places in Western India where lucerne has been well and successfully grown, the yields are not widely different. At Surat in 1906-07 an average yield of 29,400 pounds of green fodder were obtained from lucerne six months old at the commencement of the experiment, and this represents about the amount which one may expect to obtain.

The yield in the second year is often considerably lower than the first, however well manured the crop may be. With the very highly manured lucerne previously referred to (page 147) the relative amounts in the first and second year were as follows :—

		Green fodder per acre.	
		1st year	2nd year
Sewage septic effluent	..	102,088	55,330
Farmyard manure		74,620	44,100
Poudrette		96,180	56,530

Under more ordinary conditions of cultivation, Mollison* gives the following results at Poona as being the best he had had :—

First year (1892-93)	83,793 lbs. green fodder per acre.
Second year (1893-94)	31,816 " "

This falling off is, however, excessive, and is perhaps due to the very large yield in the first year, which could not be maintained. In experiments at Manjri† with various kinds of manure, an average over all plots gave—

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 is sometimes obtained. A very fair idea of the relative results in the different years of growth can be obtained from the following figures, being the average of areas under the ridge and furrow, and bed systems.

	Yield of green fodder. lbs.
1910-11‡	.. 17,092
1911-12	.. 28,480
1912-13	.. 29,310
1913-14	.. 12,567

Here we have a case where the second year gives at least equal returns to the first, and this is probably obtainable generally if the cultivation is good, if the soil is fairly free from weeds, and if the manuring at first has not been excessive.

* *Loc. cit.*

† Manjri Agricultural Station Report, 1904-05.

‡ 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 apart, and got it well-established. Then he put in guinea grass sets in the ridge, eighteen inches apart, in the lucerne. At first the mixed crop gave a heavier yield by about 28 per cent. on the first cutting. 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.†

* Surat Agricultural Station Report, 1907-08.

† 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 are available, its growing should be considered. It has, in fact, already become a regular practice in the northern part of the Thana District from which the lucerne is sent green to the Bombay market.‡

* Dohad Agricultural Station Report, 1913-14.

† Report, Ratnagiri Agricultural Station, 1913-14.

‡ Private communication from Mr. K. V. Joshi, B.Ag.

The crop should be sown immediately after the harvesting of the *kharif* rice crop, that is to say, early in October or November, in the same manner as already described in the Deccan. Watering will have to be more frequent than on the Deccan in the cold weather on account of the higher temperature. The crop, however, has been found to yield four or five cuttings before the setting in of the monsoon, and to leave the land in good condition for the following rice crop.*

Enemies of lucerne.

It must be recognised that in Western India, lucerne is not an easy crop to grow. It requires intensive cultivation, and very little neglect will 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, Molli-son was inclined to consider it as doomed to die out, as there had been little success in combating the various pests.†

Weeds.—Of these enemies the first and perhaps the most important are the weeds, and more especially the deep rooted grasses like *hariali* (*Cynodon dactylon*), or *kunda* (*Saccharum spontaneum*) and *lavala* (*Cyperus rotundus*). It is those weeds that seem to make long continued cultivation of lucerne on one site impossible, and unless absolutely thorough cultivation of the land and removal of the root stocks is carried out before planting, it will be smothered long before the plot is old. These and similar grasses form the worst enemies not only here but everywhere where lucerne is grown.

It is folly, however, to sow lucerne in foul land, and it would be far better to keep the land fallow for a year and in the meantime cultivate the land thoroughly, continually,

*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 quickly lose all connection with the ground, and then feed entirely on the lucerne plant, twining round it until it is killed. The dodder plants flower about the same time as the crop, and its seeds, though much smaller than those of the lucerne, get mixed with the latter, and are carried wherever the seed is carried and planted. There is, however, another danger in places where 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*).

*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.† 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

* Poona Agricultural College Magazine, Vol. VI, page 180.

† Bombay Agricultural Leaflet No. 12 of 1915.

‡ 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 :—

	Rs.	a.	p.
Wages of two coolies at 5 annas	0	10	0
Cost of 1½ lbs. of sulphur ..	0	3	0
Cost of charcoal ..	0	1	6
	0	14	6

It was feared that fumigation would prove difficult in black soil where large cracks extend in every direction, but it has been found practicable to operate on those soils if an extra coolie be employed to assist in scraping loose soil over the cracks. In this way it was found that the sulphur fumes spread through an area varying from one-tenth to one-half of a *guntha*† 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,

* Poona Agricultural College Magazine, Vol. VII (1915), page 79,

† 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 aphid and the lucerne caterpillar (*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 aphid.—The aphid 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

* 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 aphid 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 aphid attack ; in 1894, he stated that aphid 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 aphid 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 aphid 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 aphid climb on to the young tender shoots which spring up very quickly after every cutting, and kill these off. The plants in consequence get weaker and weaker at each cutting.

* Private communication to the author.

“ If the aphid is recognised too late a safer plan would be to spray the crop thoroughly with any contact poison like incosopol or crude-oil emulsion. This will cost from Rs. 3 to Rs. 4 per acre.

“ Living among the plant lice (aphid) 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 aphid 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 aphid, 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 aphid, 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.

* 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

* 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† 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

* See Reports, Poona Experiment Farm, 1893-94 and 1894-95, particularly.

† Scientific Memoirs by Medical Officers of the Army in India, Part X (1897), p. 124.

the 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.†

* Mem. Agric. Dept. Ind. Botanical Series, Vol. VII, No. 4 (1915).

† 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 Ajrekar (*loc. cit.*) found that they remained capable of germination for at least sixteen months, but not much longer than this, and suggested that by growing other crops for two years or more, the fungus might be starved out. Apart from this the only plan apparent at the present moment would be to sterilise the soil, either by heating (as in the *rab* process for rice seed beds), or by chemicals. In 1893 the use of soil treatment with copper sulphate solution did not, in Mollison's experiments, check the disease, and I think it is generally recognised that such treatment of the soil with chemicals is not possible as a practical method. This throws us back on the policy of long rotation free from lucerne on land which has proved to be infected, or of burning or heating the surface soil.

At the present moment this blight is not however a 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* 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.†

* See Thompstone—Agricultural Journal Ind., Vol. IV, page 334 (1909).

† 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 been 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. Molison 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

* 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* or 240 pounds. The seed obtained, when fresh, should be plump and glossy, and mostly rich brown in colour, and free from admixture with weed seeds of any kind.

Lucerne as a Fodder.

As with other crops grown for fodder, lucerne may be cut at various stages of growth, and it is important to determine the best time, so as to gain the greatest amount of good fodder, do the least injury to the plant, and 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 aphids 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.

* United Provinces, Bulletin No. 6 (2nd edition), 1911.

According to experiments elsewhere (Kansas)* the amount of moisture in the crop as cut, was as follows :—

	Per cent. moisture.
Cut when first flowers appear ..	74·6
Cut when half in bloom ..	69·7
Cut when in full bloom ..	64·2

As flowering proceeds the crop thus rapidly gets to contain far less water, and the digestibility of the protein also decreases from 90·2 to 81 per cent.† Generally speaking it is considered that the maximum yield of lucerne, and the largest amounts of valuable food will be obtained if it is cut when about half in flower. “ It will be a more serious error to cut too early than to cut too late.‡ ”

Perhaps some of the conclusions obtained at Utah§ with regard to the value of the crop cut at different stages are worth quoting.

These are—

1. The early cut lucerne contains the highest per cent. of proteids and fat, and the lowest per cent. of fibre. The former 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

* Kansas Agricultural Experiment Station, Bulletin No. 155 (1908).

† See Soderbaum—K. Land Akad. Handl. Tidski, Vol XL, (1901), page 364.

‡ Widtsoe.

§ 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

* Thompstone—*loc. cit.*

cannot well be made into hay. Mollison rather took this view, but the fact is that if it is carefully made, lucerne provides excellent hay. " It should be cut when beginning to flower, and allowed to dry before stacking. It should be handled as little and as carefully as possible, or the leaves which are the most nutritious part of the plant are shattered and lost. In hot countries it very rapidly dries ; and when thoroughly cured, it may be made into stacks, and baled in the ordinary way. The whole process is extremely simple : but care must be taken to cure it well or heating takes place in the stacks or bales. The best lucerne hay is of a bright green colour, but its colour is readily changed to yellow or brown by the effect of rain or even dew, and by heating in the stack (Thompson).

At present, and for a long time to come probably, lucerne will be used for other purposes than hay making. The demand for green fodder is so great that a valuable material like lucerne is not likely to be dried into hay during the long dry weather, and in the rains it is impossible to make hay, and silage would be much more likely. But even its extensive use for silage is not probable and in any case we have hardly any Indian experience in the matter. Though good silage was made at Ganeshkhind in 1909* yet the loss in weight (71·3 per cent.) was so great that this can hardly be taken as a fair example. Outside India, though quite useful for silage making, it is found to have its own difficulties, and needs chopping and very close packing to prevent a large amount of spoiling.

But lucerne is essentially a crop for cutting green and feeding direct to stock. For this it has no rival among leguminous crops over the greater part of Western India, and together with fodder *jowar* and maize would seem to be likely to go more near to solving the fodder problem in Western India than any other method yet suggested.

* 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,

* U. S. Department of Agriculture, Bureau of Plant Industry, Bulletin No. 23 (903).

and from the first it gave good results in some places in the *rabi* season. When planted in September, and when water was available in abundance it remained on the ground till June, yielded 17,286 pounds of green fodder per acre and was readily eaten by stock.* Similar results were obtained in the following year, and it was furthermore discovered that it must not be planted later than September or the yield will decrease. Two years later 7½ tons of green berseem were obtained per acre,—but over much of the area where it was planted, the water-supply was not reliable enough, and there was found to be too much salt in the land for the berseem to tolerate.† By 1909 it was considered by Henderson to have been conclusively proved that this crop grows very well in Sind, and he added that “it is a very valuable introduction and its extended cultivation is of the greatest importance on perennial canals. As a restorative crop none of the other pulses can be compared with it and none except 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

* Report, Mirpurkhas Agricultural Station, 1904-05 and 1905-06.

† Henderson—Mirpurkhas Agricultural Station Reports, 1905-06, 1906-07 and 1908-09.

‡ Henderson—Mirpurkhas Agricultural Station Report, 1910-11.

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.† I understand, however, that it was planted in the rains, and this accounts for the failure. One or two experiments in Poona since have not been very promising. In 1913-14‡ for example berseem was sown as a *rabi* crop. It gave its first cutting within two months, but did not do well after this, did not branch, and produced seeds early in the season. At Nadiad (Gujarat)§ it was sown in November in 1912, gave good germination and two cuttings, yielding crops in the latter part of February (8,120 pounds per acre) and in the third week in April (2,464 pounds per acre), and giving a total yield of 10,600 pounds of green fodder per acre. It seemed to go off when the hot weather started. As the growing of this crop cost Rs. 185

* See Marriott—Agricultural Journal Ind., Vol. X (1915), page 81.

† Poona Experimental Farm Report, 1894-95.

‡ Agricultural College Agricultural Station Report, 1913-14.

§ Nadiad Agricultural Station Report, 1912-13.

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 good 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

* Dohad Agricultural Station Report, 1913-14.

† Alibag Agricultural Station Report, 1913-14.

‡ Foaden and Fletcher—Text-Book of Egyptian Agriculture, Vol. II, page 462.

§ Agricultural Journal of India, Vol. X (1915), page 81.

some figures given by Foaden.* He determined the amount of nitrogen in the soil at various stages in the growth of a berseem crop, and found in two cases (A and B) percentages of nitrogen as follows :—

	A.	B.
	p. c.	p. c.
Nitrogen in Soil—		
(1) before sowing ..	·099	·101
(2) after first crop ..	·110	·116
(3) after second crop ..	·113	·111
(4) after third crop ..	·105	..
(5) after fourth crop ..	·099	..

The increase during the early part of the growth is very great indeed, but it disappears largely if the crop is allowed to mature completely. Apart from this it is considered that the roots contain about fifty-eight pounds of nitrogen per acre, and apart entirely from the crop being fed off, this will be retained in the soil.

Rotations for Berseem.

Berseem enters into cultivation in the ordinary rotation of crops. There is no need to give the rotations found successful in Egypt, as the following have been found useful and satisfactory by Henderson in Sind :—†

I. Two years' Rotation.

	1st year.	2nd year.
<i>Rabi</i> crop ..	Berseem ploughed in	Berseem allowed to seed.
<i>Kharif</i> crop ..	Cotton.	<i>Bajri</i> or <i>Jowar</i> .

* United States Department, Bureau of Plant Ind., Bulletin No. 62.

† Mirpurkhas Agricultural Station Report, 1910-11.

II.—Three years' Rotation.

	1st year.	2nd year.	3rd year.
<i>Rabi</i> crop ..	Berseem ploughed in	Berseem allowed to seed	Wheat.
<i>Kharif</i> crop ..	Cotton.	Fodder <i>Jowar</i> .	<i>Bajri</i> or <i>Jowar</i> .

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

*Marriott—*loc cit.*

conditions which prevail during its growth. It is cut when fifteen to eighteen inches high, and should not be in need of water when cut, as it ought to begin to grow at once after the cutting. Hence it should be watered ten days before cutting, and cut again in thirty-five to forty-days. If sown early it will give five to six cuttings. The early cuttings are very watery, and the later cuttings only are used in Egypt to make hay. The fifth cutting with early planted berseem or the fourth, with the crop planted later, is usually allowed to seed.

Yields of Berseem.

The actual yields from berseem in the Punjab and Sind where it is recognised as a success have varied very much. At Ferozepore it gave 34,977 pounds of green fodder per acre on good manured land in 1912-13. At Lahore, in 1913-14, it was sown early in October, and a cutting was ready by November 20th, the total yield for the season being 35,809 pounds per acre of green fodder. Another plot on the same farm gave 53,515 pounds of green fodder per acre in six cuttings, but this had grown a poor crop of berseem in the previous year. This suggests that one crop,—even a poor one—encourages in the soil the particular organism needed to inoculate the roots, and a second crop is likely to grow much better than the first. In this case the amount per acre obtained at each cutting was as follows :—

	lbs.
1st cutting	.. 4,978
2nd "	.. 8,032
3rd "	.. 12,784
4th "	.. 13,940
5th "	.. 10,912
6th "	.. 2,870

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 Mirpurkhas† it is sold in the bazar at eight annas per maund of eighty pounds and a single standing crop has fetched Rs. 10 to 12 per acre. At Sukkur a single cutting from an acre was sold

* 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).

† 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.†

Berseem Seed.

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

* See Means—United States Department of Agriculture, Year book, 1902.

† 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.†

Chicory is also a dangerous weed, which tends to create scouring in animals, and though its amount in the growing crop appears to decrease after each cutting, yet it is a considerable danger—and the likelihood of its presence needs warning against.‡ In the growing crop it should be rooted out without mercy.

Seed has still to be imported as the quantity grown even yet is hardly sufficient for extensive cultivation, 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.

* Foaden and Fletcher—Text Book of Egyptian Agriculture, Vol. II, page 469.

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

‡ Brown—*Agricultural Journal Ind.*, Vol. X (1915), page 402.

§ See Bonaparte—*Journal Khed, Agric. Soc.*, Vol. IV (1902), page 224.

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

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

valleys. In the plains it has proved of little use. It was grown experimentally in 1912-13 at the Poona Agricultural College under irrigation, and gave two cuttings amounting together to 3,575 pounds of green fodder per acre. It could not apparently stand the hot weather and died away. It is, apparently, unsuitable in fact for the semi-tropical conditions of sea level or low elevation here, but seems likely to be of great value in the colder hill regions of the country. Under these conditions Howard stated that "it will yield four crops in one year, three of which can be utilised for fodder and the last either for seed or as green-manure. The plants set seed freely during the month of June so that there is no difficulty with regard to a fresh supply for sowing. No pests have been observed on this crop when properly grown and when regularly cut. If, however, it is over-watered and if it is not cut in time, the leaves are often attacked by a fungus, but this does not reappear on the foliage of the new growth unless it becomes over ripe."

The procedure recommended by Howard for its cultivation in the Quetta valley is as follows :— .

The sprouted *shaftal* seed, at the rate of twenty pounds per acre mixed with an equal weight of dry earth, is sown in the irrigation water on the plots where it is to be grown about the latter half of August. The seeds root at once and as soon as possible a light covering of dry earth is applied. A second light watering is given as soon as the ground has dried.

A light cover crop of maize or *jowar* previously sown, is useful to protect the *shaftal* seedlings from wind and sun. This is removed in the early part of September, and thereafter the *shaftal* crop grows alone. The surface of the ground should be kept cultivated and in such a condition as to form an earth mulch. Irrigation should not be excessive, but should be given whenever the change in colour to a darker green (already noted as occurring with lucerne) announces the need for water.

The need for irrigation water is not great at Quetta until rapid growth takes place in the spring.

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 drying. Provided it is put into heaps just at the right stage, on the second day the fodder begins to get warm. At this point, the heaps are opened and the produce carried to the stack during which it dries considerably. Some little experience is needed in determining the stage at which to stack the fodder. If it is too dry, no slow after, fermentation takes place and it becomes too brittle for baling. If, on the other hand, it is stacked too damp, over-heating takes place and the final product moulds. Two months in the stack is ample for the development of the proper colour and texture, after which the hay can be baled" (Howard).

The loss of weight in hay making was about seventy-six to eighty four per cent. in Quetta, according to the stage of ripeness of the crop. "A fair average would be twenty pounds of hay to one hundred pounds of green *shaftal*" (Howard). The hay has been uniformly considered to be excellent in the neighbourhood of Quetta.

Whether *shaftal* has any future in other parts of the Bombay Presidency cannot yet be stated. The climate on the plains or on the Deccan in the autumn and cold weather is evidently too hot for it to produce a good stand of plants. Some of the higher hill regions, such as Mahableshwar and similar hill sections of the Western Ghats, where irrigation is available, might be very suitable places for the trial of this crop. Wherever it is successful it will form a most valuable addition to the fodder resources of a class of country in India where these have been notoriously scanty.

SENJI.

Senji (*Melilotus alba* or *Melilotus indica*).—This common leguminous weed in the Punjab, very similar to clover in character, is not infrequently sown in North India as a fodder crop. It occurs either as a white flowered plant (*Melilotus alba*) or a yellow flowered plant (*Melilotus indica*), and either one or the other is sown in October, and harvested in February or March. It is there said to be best grown mixed with other crops such as barley or oats. Both varieties are said to be of considerable value when fed green to milch cattle, but if allowed to ripen they are liable to cause colic. "They require rich and moist land such as the alluvial land in the beds of rivers, and should be irrigated."* Under the name 'sweet clover' the white flowered variety is grown to a considerable extent in the United States and also in the warmer part of the temperate zones elsewhere, while the yellow flowered variety

* 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†. This, I may remark, is always a difficulty at first with *Melilotus* fodder but animals soon get used to it. The crop proved a failure at Dharwar in the same season.‡

On the whole there does not seem much promise for the utilisation of these clovers except in Sind, and there, berseem is so much better that they need hardly be considered. 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

* Report, Mirpurkhas Agricultural Station, 1905-06.

† Agricultural College Station, Poona, Report, 1909-10.

‡ Report, Dharwar Agricultural Station, 1909-10.

§ 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

* 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.* As time went on the specific purposes for which *chavli* and *val* are suited became better defined: *chavli* grew best in the hot weather under irrigation, and in the rains on almost any soil but particularly on good deep land, but *val* was distinctly better as a crop after the end of the rains. Some yields obtained in Poona as a rains crop are shown as follows:—

Year.	Seed used per acre.	Yield (green) per acre.	Cost per acre.	Value per acre.
	Lbs.	Lbs.	Rs. a. p.	Rs. a. p.
1894 ..	40	12,089	17 0 0	48 0 0
1895 ..	48	7,346	13 8 0	29 8 0
1905 ..	No record.	6,981	40 0 0	No record.

These may be taken as typical of the kind of return which may be expected in the greater part of the Bombay Presidency. In Sind, where the crop had been unknown, and where, of course, it must be grown under irrigation, it has had considerable success when sown in June and cut for the first time at the end of August. The actual results at Mirpurkhas have been as follows:—†

Year.	Yield per acre.	Remarks.
	Lbs.	
1910	18,000	Second cutting very poor.
1901	16,000	No second cutting.
1912	12,000	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† 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

* See Reports, Larkhana and Landhi Agricultural Stations, 1913-14.

† 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 hay.*

Yield.—I have already indicated (page 193) the quantity of crop which has been obtained in our experiments at different seasons of the year. It may be taken that 12,000 to 16,000 pounds of green fodder per acre is a good crop when grown

* 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 obtained from cowpea in America where it is so extensively grown as a fodder crop.

Chavli as a mixed Crop.—*Chavli* forms an excellent mixture with either fodder *jowar* or *bajri* grown for fodder, and owing to its more or less twining habit it becomes thoroughly mixed with the *jowar* or *bajri* and considerably increases the feeding value of the crop. The usual plan here followed has been to grow three rows of *jowar* and one row of *chavli*, the seed being drilled. Both grow together, and the mixture is cut when the *jowar* is ready. From experiments with various pulses (*chavli*, *val*, *mug*, *kulthi*, 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 aphid (*Aphis rumicis*) which often injures the crop grown under irrigation in the hot weather. The crop is only occasionally damaged seriously with us. The attack can be detected at once by the bending over of the growing tips of the plants, the curling up of the leaves, and a general air of unhealthiness over the plants. Nothing can be done, except to cut the crop and feed green at once, and trust to getting a return from a second growth. Any spraying method for a crop like *chavli* would be out of place.

The second serious pest, not only of *chavli* but also of *val* and several other pulse crops, is a hairy caterpillar (*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† renders the possibility of such an attack here not very remote

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

† Butler—Report, Agricultural Research Institute, Pusa, 1911-12.

If such an attack does occur, the crops had better be cut down, the land ploughed at once, and the crop avoided for two years at least on the land.

Chavli as a Fodder.—*Chavli* is one of the most valuable leguminous fodder crops we have for all kinds of stock. It is rich in proteids in particular, and analyses of the very similar cowpea hay (when completely dried) grown in America are as follows* :—

	Cut in full bloom.	Cut when pods forming.	Cut when pods formed.
	Per cent.	Per cent.	Per cent.
Ether extract (fat, &c.)	4·04	3·06	5·01
Proteids	17·86	19·93	21·38
Digestible Carbohydrates, &c. ..	52·28	50·58	32·59
Fibre	18·29	18·52	29·05
Ash	7·43	7·91	11·97

This shows that the proteids increase in this case after the pods are formed, as the seeds are very rich in this constituent. When ready for feeding off the following co-efficients of digestibility of the various constituents of the fodder have been given by American authorities† with cattle :—

Dry matter	68	per cent.	digestible.
Fat	59	.. ..	.. ..
Proteids	76	.. ..	.. ..
Digestible carbohydrates	81	.. ..	.. ..
Fibre	60	.. ..	.. ..

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

* 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 1894 per acre	Yield of green fodder 1895 per acre.
<i>Chavli</i>	Lbs. 12,089	Lbs. 7,346
<i>Val</i>	7,998	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	Lbs. 12,000	First cutting only. Gave a good second cutting.
1911	.. 22,000	In three cuttings.
1912	.. 16,533	Do.

Thus we have a crop which is almost ideal as a *kharif* fodder for Sind, as it gives repeated cuttings of good fodder before ploughing into the land for the *rabi* season. The conclusion reached as a result is that "*val* as a pulse fodder is unequalled : *chavli* is next."

The present position generally is that in Western India *val* can be relied upon to give a crop of 7,000 or 8,000 pounds of

green fodder in the rains, or in the *rabi* season with irrigation. For the latter purpose it will do better than any other. In the special conditions of Sind, it is probably the best annual leguminous fodder crop for the *kharif* season.

Val is a more twining and climbing plant than *chavli* or indeed than any of the common pulses. In its early growth its tissues are very tender and soft, and hence it is delicate, and liable to slight attack by quite a number of insects. In most of the varieties the flowers are white, but one vigorous variety grown in the Konkan has purple flowers. No experiments have been made as to the relative value of different varieties from a fodder point of view.

On the whole *val* seems to prefer a medium or stiff soil—a stiffer soil than is the best for *chavli*. Grown in the *rabi* season for which it is most suitable in the greater part of the Bombay Presidency, it does not need irrigation if the water level is not far from the surface, but if a large yield of fodder is wanted, irrigation will, in nearly all cases, be of advantage in the later part of the growth, except in particularly damp places. While requiring much moisture, *val*, however, will not flourish in waterlogged places. Grown for grain, it will stand considerable drought,—even more than *chavli*, but under drought conditions the amount of fodder yielded is relatively small.

The method of cultivation is similar to that already described for *chavli*. But the land need not be so carefully prepared as for *chavli*. One special difficulty arises in this case. Most of the pulses have a certain percentage of hard seed which will not germinate without special treatment, and in this matter, *val*, in our experience, is the worst of all of them. If the seed is rubbed roughly and thoroughly with wet sand before sowing, all difficulty on this score disappears.

In growing it for seed in the Konkan, the land after removal of the rice crop is ploughed and cross ploughed.

The plough is again worked a third time, and the seed is then dropped into the furrows made by the plough. Better than this is the use of the drill when growing the crop for fodder. About thirty to forty pounds of seed per acre are required.

The crop is cut when the beans are formed, and this is about two and a half to three months after sowing. It must be cut at an earlier stage than *chavli*, as after the crop begins to ripen, the leaves get very brittle and fall off at the lightest touch. Hence it should be generally fed green and is not suitable for making into hay. Grown as a *rabi* crop, by the time it is ready, green fodder has begun to be scarce over most of Western India and it is particularly valuable. In Sind, green fodder is always valuable. I have no experience of any attempt being made to convert *val* into silage, but there is no reason to anticipate any special difficulty.

Yield.—The amount of green fodder obtainable per acre can be judged from the figures already given of the yields actually produced at Poona and Mirpurkhas. Its power of giving more than one cutting is of considerable value and enables it to produce a larger yield than otherwise would be the case. In Sind this faculty is now well 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

* 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 seems to be no use in Sind. Under all conditions of growth where successful it has only given one cutting.

* Bombay Agricultural Department, Bulletin No. 15 (1892).

† Poona Experiment Farm Report, 1895-96.

‡ Report, Poona Experiment Farm, 1897-98.

§ Report, Mirpurkhas Agricultural Station, 1910-11.

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. Mukerji† recommends taking three crops in succession for fodder, sown in June, August and November, and reaped, respectively, in August or September, October and January. Robertson suggests that it may follow a *rabi* crop, and so furnish green fodder in the hot weather at the least expenditure of water; the reaping of the crop commencing a month only after sowing.‡

Most of the *kulthi* grown in Western India is now grown in admixture with *bajri*, one row in four being *kulthi*. The system gives a very good mixed fodder.

When grown alone the yield which may be expected has been already indicated. Mukerji (*loc. cit.*) says that five tons of green fodder can be obtained per acre. This, however, would be a high yield on most of the soils on which *kulthi* is grown with us. As already noted the fodder is very good in quality. If the plants are cut when in flower, it is excellent for all farm animals (Mollison), and especially in mixtures is considered as particularly good for milk animals. Mukerji notes that a mixture of *kulthi*, unripe *bael* fruits, and *kanta-notia*

* Text Book of Agriculture, Vol. III, page 83.

† Handbook of Indian Agriculture (3rd edition), page 203.

‡ 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	7·5	..
Ash	4·1	..
	<hr/>	
	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

* Piper—Forage Plants, page 557.

numerous in short, erect axillary racemes. The pods are flat, $1\frac{1}{2}$ to 2 inches long, and about seven seeded. '*

Experiments in Western India as a fodder crop have chiefly been made in Sind, where it shows considerable promise, for growth in the *kharif* season. At Mirpurkhas, planted in June, and cut for the first time in August, it has been reported on as follows :—

1910-11.—Excellent fodder, relished by cattle. The second cutting was poor, but the first cutting gave 13,000 pounds of green fodder per acre. The local variety grew well, but another with large pods, obtained from Karachi, was preferred.

1911-12.—12,000 pounds of green fodder 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. †

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

In the remainder of the Bombay Presidency few experiments have been made with *guar* as a fodder crop. At Dharwar once it was established it was found to resist drought well,—but did not appear to be suited to black cotton soil.

Soil and Cultivation.—In fact, in *guar* we have a crop essentially suited to sandy or alluvial soils, and under these conditions it can be grown with success by practically the same methods already described in the case of *chavli*, though it can be planted perhaps a little closer than in the case of the

* Piper—Forage Plants, page 557.

† Reports, Mirpurkhas Agricultural Station, 1910-11, 1911-12, 1912-13.

‡ 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.† Hitherto it has always been fed green here when grown as a fodder crop, and there seems no experience as to its value for hay making or for silage. The analysis in my laboratory of two lots of young fresh *guar* plants grown at Loni near Poona gave the following figures :—

	(1)	(2)
Moisture	.. 77·0	73·8
Ether extract (fat, &c.)	.. 0·7	0·8
Proteids	.. 4·6	4·3
Digestible carbohydrates	.. 10·5	8·9
Fibre	.. 4·0	7·9
Ash	.. 3·2	4·3
	<hr/>	
	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.

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.*

*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 further experiment. A second crop cannot ever be obtained.

Soybeans are said to grow very well with maize, and are very commonly grown in America in admixture with it in alternate rows. The crop is then often converted into silage, though this would be hardly likely to be done here.

* 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 than *chavli*, and hence less palatable to stock, while there is more waste in feeding. The average composition is given by Voorhees* as follows, with the percentage of digestibility:—

				Composi- tion.	Percentage of digesti- bility.
				p. c.	p. c.
Moisture	..	..	(..	75.1	
Ether extract (fat, &c.)	..	..	)..	1.0	55
Proteids	..	..	..	4.0	78
Digestible carbohydrates	..	..	..	10.6	77
Fibre	..	..	..	6.7	45
Ash	..	..	..	2.6	
				100.0	

It must be recognised that soybeans are as yet in a very early experimental stage here. They are, however, proved to be definitely a failure as a rains crop, but show considerable promise as an irrigated *rabi* crop. It is for this latter purpose they are here suggested.

XVII.—Peas.

The ordinary field pea of India (*Pisum sativum*) is, when grown separately, of little use as a fodder crop. It only gives a comparatively small yield when grown in the cold weather, and if grown in the rainy season the plants will mildew and only give an insignificant return.† At the same time it is generally recognised throughout Western and Northern India that the plant furnishes very valuable fodder,‡ and is one which grows very well indeed in mixture with other crops, and particularly with oats. As a result while one may say that peas alone are never grown for fodder purposes, oats

* Voorhees—Forage Plants, pages 266 and 366.

† Poona Experiment Farm Report, 1893.

‡ See Watt—Commercial Products of India, under *Pisum*.

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 farm-yard 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

* 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 2½ months after seeding and should be harvested when the oats are in the milk stage and the peas are forming pods. If needed for feeding green it need not all be cut at once, and a crop from a single seeding may last in very good condition for at least eight or ten days. If this is to be done, the cutting should begin a little before the stage already recommended. If continuous green feed is needed, this can be obtained by seeding several plots at intervals of a few days from October to December.

The yield of the mixed crop is very variable. When young the fodder is very watery, but at the stage recommended it is as rich in feeding material as most other green crops, and, thus cut, the yield of green fodder with a well grown crop varies from ten to twenty thousand pounds per acre. I may give some examples of yields actually obtained here. At the Poona College Dairy Farm, where it is a regular crop, seed sown in October gave crops of 15,208 and 11,200 pounds of green fodder per acre in January in different parts of the farm in 1911, and this represents about the average yield there. At Manjri in the same year 10,038 pounds per acre were reaped, the cost being Rs. 51 per acre and the value of the produce Rs. 84. The yields elsewhere are not widely dissimilar.

It has been customary to feed the crop green, but it makes excellent hay, and at the time of the year when it is ready, it can be made into hay without any difficulty. If this is done, it should not be cut later than the stage already stated.

I have not got any analyses of local grown fodder, but the following are American figures for a crop grown from seed

consisting of two bushels of peas to one and a half bushels of oats, and hence containing more peas than recommended above :—

	Per cent.
Water	.. 79·4
Fat (Ether extract)	.. 0·7
Proteids	.. 2·1
Digestible carbohydrates, etc.	.. 10·0
Fibre	.. 6·2
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.† 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

* Voorhees—Forage Crops, page 187.

† 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.† It is either produced under well or canal irrigation and the system employed differs considerably in the two cases. If grown under well irrigation it grows taller than in the other case, and pays better. In either case *methi* fodder is the main-stay of the work bullocks during the hot weather in many parts of the Nasik district, and most of the people cultivating under well irrigation devote about one-fifth of the area to the growth of this crop. The proportion is usually about one acre for seven bullocks, and it is the chief food in the day time for a month or so during the hot weather.

The soil used for the purpose is a well-drained medium black soil with *murum* underlying it. If a thin layer of the so-called *shadu* lies between the black soil and the *murum* the best conditions are supposed to be reached. Abundance

* Fosden and Fletcher—Text-Book of Egyptian Agriculture, page 561 (1910).

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

of lime in the soil appears to be necessary. If grown on lighter and poorer soils more irrigation water is needed, and less succulent fodder is obtained. Undrained soil leads to attack by aphids, and checks the tillering 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

* See Klemmer and Kruger—Centralblatt für Bakt. (II), Vol. XL (1914), page 256.

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

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 aphid, and this particularly affects the late sown crop and usually appears in March or April. The crop sown in October and November seems to escape the attack.

By far the greater part of the crop is grown under well irrigation as described. But where canal water is available it is also produced though the methods differ slightly. Under these circumstances it is usually taken after rice or after groundnuts. The land is ploughed twice, the seed 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 (*Crotalaria 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

‡ 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

* 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.

* 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.† 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

* Poona Experiment Farm Report, 1903-04.

† 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

* Kirkoe Dairy Farm Report, 1905-06.

† Landhi Agricultural Station Report, 1913-14.

only value appears to be to keep light poor sandy land under some sort of leguminous herbage, either without any irrigation or with a minimum of irrigation, for it seeds itself and will possibly give a crop on such land year after year with the minimum of attention. I cannot say that the possible utility of the crop seems to be great.

The following crops have after trials so far given no promise of being useful :—

*Japan Clover** (*Lespedeza striata*).—This has been tried in Sind (Mirpurkhas 1908), at Dharwar (1909), and at Poona (1909). At none of these places has it shown any promise. Considerable difficulty has been found in getting the seed to germinate, and the crop shows no likelihood of being useful.

Vetches (*Vicia sativa*) were tried as a rains crop in Poona as long ago as 1893.† They were put in in June and germinated well, but only produced plants giving a very few flowers and no seed. The crop was considered to have no promise of being a success. A second experiment in 1912 was no more promising, and the crop was shown to be unable to stand the hot weather‡.

Sainfoin (*Onobrychis viciaefolia*) has been experimented with at Poona as long ago as 1893‡. It, however, proved after repeated trials a total failure as a rains crop, and also in the cold weather. It did even worse than vetches as a rains crop, and the seedlings soon died.

Lathyrus sylvestris var, *Wagneri*.—A few years ago this crop was boomed as a first class perennial fodder crop, and it was tried in many parts of the world. It has, however, proved a general failure almost everywhere. In Poona, it was grown for three years but proved “a miserable failure,”

* Mirpurkhas Agricultural Station Report, 1908-09; Dharwar Agricultural Station Report, 1909-10; Poona Agricultural College Station Report, 1909-10.

† Poona Experiment Farm Report, 1893.

‡ Report, Agricultural College Station, 1912-13.

as elsewhere in India. In the report of the Poona Farm (1893) the following remarks were made by Mollison: "The plot on the Poona farm has survived more than a year, but in the hands of an ordinary cultivator it would have been extinct long ago, because the expenses incurred in weeding and watering have already far exceeded any prospective return which the most enthusiastic cultivator could forecast. I must give the plant credit for enormous root development, but unfortunately this growth is in the wrong direction, for nothing that could be called fodder has yet been gathered." The crop continued in a gradually dying condition for two years more and then disappeared.

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