CALCUTTA
SUPERINTENDENT GOVERNMENT PRINTING, INDIA
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REPORT

OF THE

Agricultural Research Institute and College, Pusa

(*Including the Report of the Imperial Cotton Specialist*)

1915-16

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1916

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1915-16.

REPORT OF THE DIRECTOR.

(J. Mackenna, M.A., I.C.S.)

I. Charge and Staff.

Charge. I succeeded Mr. B. Coventry, C.I.E., as Agricultural Adviser to the Government of India and Director, Agricultural Research Institute, Pusa, on the 1st April 1916, when he retired from the service of Government. Mr. Coventry has been identified with the Institute since its foundation and has been responsible for its development and growth. It is now one of the best equipped establishments of the kind in the East. Mr. Wynne Sayer was Assistant to the Agricultural Adviser throughout the year.

Staff. The following changes in staff took place during the year.

Mr. J. W. Leather, V.D., F.I.C., Imperial Agricultural Chemist, proceeded on combined leave from 16th September 1915, preparatory to retirement. He has since joined a Garrison Battalion of the Cheshire Regiment as a Major. Mr. Jatindra Nath Sen, M.A., F.C.S., Supernumerary Agricultural Chemist, was appointed to act as Imperial Agricultural Chemist.

Mr. A. Howard, C.I.E., M.A., and Mrs. Gabrielle L. C. Howard, M.A., the Imperial Economic Botanists, took one month's privilege leave from 10th November 1915.

Mr. E. J. Butler, M.B., Imperial Mycologist, returned from leave on the 16th November 1915, and resumed charge of the section from Mr. F. J. F. Shaw, B.Sc., A.R.C.S., who had been officiating.

Mr. T. Bainbrigge Fletcher, F.L.S., F.E.S., F.Z.S., Imperial Entomologist, held charge also of the duties of the Imperial Pathological Entomologist from the 9th August 1915, in place of Mr. F. M. Howlett, B.A., F.E.S., Imperial Pathological Entomologist, on leave.

Mr. C. M. Hutchinson, B.A., Imperial Agricultural Bacteriologist, was on privilege leave for one month from 7th September 1915.

The Agricultural Section was in charge of Mr. S. Milligan, M.A., B.Sc., up to 2nd June 1916, when he was transferred to Bengal as Officiating Director of Agriculture and Mr. G. S. Henderson, N.D.A., N.D.D., was appointed to officiate as Imperial Agriculturist.

Mr. W. A. Davis, B.Sc., A.C.G.I., F.C.S., was appointed to the special post of Indigo Research Chemist, and posted to Pusa. He joined his appointment on the 20th May 1916.

II. Work of the Institute.

Scientific work. The scientific work of the Institute during the year is indicated in the reports of the various sections.

Training. The training of students in post-graduate courses was continued and short courses were also given in cattle management and sericulture.

In the section of Agricultural Bacteriology two students completed their course during the year under report and returned to their respective Provinces. An Assistant deputed by the Assam Department of Agriculture is now under training.

In the Botanical Section an Assistant deputed by the Burma Department of Agriculture was trained during the year in work connected with wheat-growing.

In General Entomology two students completed their training and at the end of the year under report one agricultural graduate is taking this course.

In the Mycological Section, two students completed their course during the year.

An Assistant deputed by the United Provinces Department of Agriculture is undergoing training in general agriculture in the Agricultural Section.

Besides the regular students referred to above the following visitors also worked in the laboratories :—

Mr. Karm Chand Mehta, M.Sc., Professor of Botany, Agra College, and Mr. Bamanji Nowroji Vakil, B.Sc., of Bombay, worked in the Mycological Laboratory from 3rd March to 27th March 1916, and 15th March to 25th April 1916, respectively. Mr. Mahdi Hasan, a private student from Hyderabad, Deccan, worked in the Entomological Laboratory for about four months. Mr. Deoki Nandan, M.R.A.C., took a course in general agriculture, mycology and entomology.

Three students took the short course in sericulture and a graduate of the Lyallpur Agricultural College took the special course in cattle breeding and dairying.

III. Publications.

The Agricultural Journal of India, Scientific Memoirs and Bulletins continued to be issued during the year. The Department published during the year 13 Memoirs and 6 Bulletins; 6 Memoirs and 4 Bulletins are in the press. The Proceedings of the Inter-Provincial Jute Conference (1915) and of the 9th Meeting of the Board of Agriculture in India (1916), were also issued during the year. A Bengali version of Bulletin No. 48, has been published and copies

distributed free in the important silk centres of Bengal. A revised edition of the Manual of More Deadly Forms of Cattle Disease in India was also published during the year. A special number of the Agricultural Journal of India was issued including all papers of agricultural interest read at the Third Indian Science Congress held at Lucknow in January 1916. A revised edition of Bulletin No. 39 and the second edition of Bulletins Nos. 52 and 53, are in the press. The grant of Rs. 29,000 permanently sanctioned for publications was continued during the year under report. Owing to the continued rise in the prices of paper and other materials, strictest economy had to be exercised to keep down the expenditure within the sanctioned limits.

IV. General Administration.

Buildings and Works. During the year under report four additional quarters for the subordinate staff were completed and four more quarters are under construction. The female ward for the Pusa Hospital was also completed during the year. Necessary funds have been allotted for the installation of electric lights and fans in the European bungalows and the work is in the hands of the Public Works Department. The new ice machine referred to in last year's report has been installed. Several minor works were also done during the year out of the grant of Rs. 5,000 placed at my disposal in the civil works budget of the Public Works Department.

Library. The third edition of the catalogue of the Pusa Library, was issued during the year. In addition to the foreign bulletins, memoirs, reports, etc., which are received in exchange from different parts of the world, over 300 volumes were purchased for the library during the year.

Pusa Schools. The number of pupils attending the Pusa High School at the close of the year was 185. In March 1916, the school sent up seven boys for the Matriculation Examination of the Calcutta University and of

these five passed in the first division and one in the second division.

The Lower Primary Girls' School remained closed during the greater part of the year on account of the death of the mistress of the school. It is hoped that the vacancy will soon be filled as there is a demand for female education

General Health of the Station. The general health of the station during the year under report was satisfactory. Relief was afforded to 10,458 persons at the Pusa Hospital, of which 10,223 were treated in the out-patients department and 235 in the indoor department.

The average daily attendance was 68·07 in the out-door and 12·01 in the indoor departments.

The total number of deaths in the hospital were 11. Most of these cases were brought to the hospital in rather advanced stages of illness.

Occasional outbreaks of cholera in the villages lying in the immediate vicinity of Pusa during the months of September, November and December 1915, became a source of great danger to the Estate. Preventive measures were promptly taken, and the wells were thoroughly disinfected with the result that the disease did not enter the Estate.

Thirty-two primary and eight re-vaccinations were done during the year.

V. Accounts.

The total expenditure during the financial year 1915-16 was Rs. 4,63,817, as under :—

	Rs.
Office of the Agricultural Adviser to the Government of India and Director of the Institute	2,00,852
Chemical Section	31,699
Mycological Section	32,231
Entomological Section	41,297
Pathological Entomological Section	16,728
Botanical Section	43,803
Bacteriological Section	28,436
Agricultural Section	68,771
Total	4,63,817

In addition to the above a sum of Rs. 23,502 was spent out of the provision of Rs. 23,560 made under "Sugar Experiments" in the budget of this Department for 1915-16, in connection with the engagement of Mr. W. Hulme as Sugar Engineer in the United Provinces.

A sum of Rs. 15,000 was paid as a grant-in-aid to the Indian Tea Association.

The principal items of expenditure under the annual grant of Rs. 10,000 placed at the disposal of the Agricultural Adviser to the Government of India for special Agricultural Experiments were as follows:—

	Rs.
Purchase of a small sugarcane crushing plant required for experiment by the Agricultural Chemist, United Provinces . .	500
Cost of additional machinery for sugar plant required by Mr. Hulme	6,000
Purchase of silk yarn for sericulture experiments at Pusa	194
Experimental cotton cultivation conducted by the Imperial Cotton Specialist . .	1,500
Pay of a Veterinary Assistant in connection with cattle breeding and of a Fieldman for mosquito experiments	863

The gross receipts during the year from the sale of farm produce, milk, publications of this Department and other articles amounted to Rs. 15,340 as against Rs. 16,843, in the previous year.

VI. Conferences.

An informal conference on the subject of Agricultural Education was held at Pusa on the 4th and 5th February, 1916, under the presidency of the Hon'ble Mr. C. H. A. Hill, C.S.I., C.I.E., I.C.S. It was composed of officials of the Agricultural and Education Departments, Mr. Fremantle, Collector of Allahabad, one non-official member and myself. The ninth meeting of the Board of Agriculture in India was also held at Pusa in the same month. It was attended by 47 members and 24 visitors and was pre-

sided over by Mr. Coventry. The arrangements were made by Mr. Wynne Sayer, Assistant to the Agricultural Adviser to the Government of India, who also acted as Secretary to the Board.

VII. Visitors.

His Honour the Lieutenant-Governor of Bihar and Orissa, visited the Institute on 6th August 1915. During the year under report the Hon'ble Mr. C. H. A. Hill, C.S.I., C.I.E., I.C.S., Member-in-Charge of the Department of Revenue and Agriculture, the Hon'ble Mr. R. A. Mant, I.C.S., Secretary to the Government of India, Department of Revenue and Agriculture, Mr. Van Geuns, Editor of the *Soerabajasch Handelsblad*, Java, and others visited the Institute.

REPORT OF THE IMPERIAL AGRICULTURIST.

(G. S. Henderson, N.D.A., N.D.D.)

I. Administration and Tours.

Mr. Milligan held charge of the post till the 2nd June 1916, and then handed over charge to me on his being appointed to the post of Director of Agriculture, Bengal.

The senior members of the staff remained practically unchanged. An appreciative note was left by Mr. Milligan of their services.

Mr. L. S. Joseph acted for Mr. Judah Hyam, Veterinary Overseer, for a month and then volunteered for military duty, on the transport of horses to Egypt, for two months. He again volunteered for military duty and went to Mesopotamia on the 6th July 1916.

Tours. Mr. Milligan examined students at the Cawnpore Agricultural College in September 1915, also visited Hoshangabad and Panna State in Central Provinces and the Kamrup sugarcane estate in Assam in January.

II. Training.

There were during the year under report three students, post-graduates, who got a practical insight into the working of the farm and the details of steam cultivation.

III. Farm Cultivation.

The rainfall was 51·37 inches as compared with 54·88″ last season. Heavy rains fell in August and the new 18″ drainage pump was working during most of the month. It cleared the stagnant water in a satisfactory fashion. The October rains were poor.

Cropping. The major portion of the farm is cropped for the purpose of feeding the breeding herd, work cattle, etc. The stock at Pusa averages about 430 head, this requires an enormous amount of stuff. In one day 100 maunds of green fodder, 25 maunds of oat straw and 17

maunds of grain are supplied. When the seasons for green fodder and silage are finished, over two tons per day of oat straw are needed. Fifteen thousand maunds of silage were used during the year.

In the past season there were 280 acres of land double cropped, mostly maize in kharif, sown with *arhar* (*Cajanus indicus*) reaped in rabi, or maize followed by oats in rabi. 147 acres were single cropped. The area of crops was over 700 acres. Fallows were 120 acres.

In addition to the oats, maize and *arhar* supplied as concentrated food, seed has to be kept for the next season. The budget, buildings and equipment are all insufficient for the area cultivated. Bamboo *kutcha* sheds have to take the place of more permanent structures. The roofs of the breeding herd buildings, a part of the old horse breeding establishment, are in a precarious condition. A mile or two of light tramway would facilitate the working of the estate.

The set of steam tackle (Fowler's double engine, K. class, single cylinder) worked 254 days and the following work was done :—

Ploughing with disc plough	260	acres.
Disc harrow	1,549	,,
Grubber	735	,,
Roller	529	,,
Zig-zag harrow	195	,,

The best work in one day for each operation was 7 acres ploughed, 22 acres harrowed, 18 acres grubbed, and 27 acres rolled.

All crops were drilled and then from time to time intercultured with Wallace's horse hoe and hand weeding was reduced to a minimum.

Crop Experiments. About 20 acres of sugarcane were grown without any irrigation; 6,639 maunds of cane were sold to a factory.

The series of permanent rotational and cropping experiments were continued.

A series of green manurial experiments in conjunction with the Imperial Agricultural Bacteriologist was continued.

The new experiment field is being tested uniformly with oats in order to select plots of similar output.

The *rabi* crop of oats all over the farm was exceptionally good. In the weighed plots the best yields were, wheat 30 maunds per acre, oats 39 maunds per acre and barley 24 maunds; the total yields of grain exceeded the last year's yield by over 1,600 maunds.

IV. Live-Stock.

Cattle Breeding. Two herds are being kept at Pusa, one of selected Sanhiwal (Montgomery) cows and their descendants and the other of cross-bred Ayrshire-Sanhiwal cattle. From want of ground and buildings, however, both herds are kept together. There are 7 bulls, 2 Ayrshire bulls (Carston Royal Scotch and Lessnessock Wildfire), 107 cows, 59 bull calves, 103 cow calves and 25 young cross-bred stock.

In the pure bred herd 4,000 lb. of milk in a lactation period has been accepted as the standard, anything less will fail to qualify for admission. The herd is kept in 5 groups with a separate bull for each group, this will enable the herd to be carried on for a considerable time without outside blood.

Among the cross-breds the heifers produced by the first Ayrshire bull "Mossgeil Titanic" (now dead) will be crossed by the produce of "Lessnessock Wildfire."

During the year there were on a daily average 119 customers for milk, the average number of cows in milk was 55, and the average daily yield of milk was 35 gallons including the milk taken by the calves.

Two cows, Mookhia and Roopiria, each produced over 490 gallons.

Nine animals were sold from the herd for breeding purposes at nominal rates to approved breeders.

Sheep Breeding. Operations have been continued as described in last year's report. The sheep now number 211 head.

V. General.

Drainage. The new bund round the south of the estate was completed and a number of drains in the Brickfield and other low places were dug. The drainage system is very complete now and with the exception of two fields which are outside the scheme any ordinary flooding can be dealt with expeditiously.

Levelling. Some levelling was done with bullock scrapers but nearly all fields still require some low places filled up.

A new 4 feet 6 inches threshing machine was used for threshing the oats, etc. The best day's work was just under 400 maunds of cleaned oats.

VI. Programme of work for 1916-17.

The following are the lines of work in progress :—

Major investigations.

1. Economics of cultivation of steam engines.
2. Investigation of most suitable rotation and manuring for land devoted to cattle feeding.
3. Trials of various leguminous fodder crops.
4. Study of inheritance of characters of dairy cattle by crossing.
5. Building up of milk pedigree in cattle by selection.
6. Manurial experiments with fermented green manures in collaboration with the Imperial Agricultural Bacteriologist.

Minor investigations.

7. Inheritance of wool characters in sheep.
8. Experimental tillage in growing of maize and sugarcane.
9. Improvement of pastures.

REPORT OF THE IMPERIAL AGRICULTURAL CHEMIST.

(J. Sen, M.A., F.C.S.)

I. Administration and Tours.

Charge. The section was in charge of Mr. (now Major) J. W. Leather, V.D., F.I.C., up to the 15th September 1915 when he proceeded on long leave preparatory to retirement. He has since joined the 3rd Battalion, Cheshire Regiment. The First Assistant was in charge of the current duties from 16th September to 6th November 1915 when I took over charge of the section as Officiating Imperial Agricultural Chemist.

Establishment. Mr. P. N. Mehta, B.A., was appointed an assistant on 10th July 1915.

Mr. B. M. Amin, the Third Assistant, has been deputed to work under the Indigo Research Chemist with effect from the 15th June 1916.

Babu Upendra Nath Sen Gupta, B.A., was appointed a probationary assistant from the 15th June 1916.

Tours. Major Leather visited Simla in July to confer with the Commissioner of Northern India Salt Revenue about the experiments on refining saltpetre and also went to Cawnpore in September to arrange about draingauge work.

I went to Sabour in December to see to the harvesting of my experimental plot of paddy there.

II. Education.

Babu Upendra Nath Sen Gupta joined this section as a private student but has afterwards taken up appointment as an assistant.

III. Meteorology and Draingauges.

In addition to the usual records for the Meteorological Department, records of atmospheric pressure by means of a

barograph have been maintained. Work in connection with drainguages here is being kept up. The waters and crops from the Cawnpore drainguages are also being analysed as usual.

IV. Infertility under trees.

The problem of the occurrence of infertile patches in the soils under trees is being studied. It has been found that in many cases, though not in all, this is associated with a decreased permeability of the soils and the presence of soluble salts.

V. Rice.

The Rices of Bihar and Orissa. In view of the importance of a chemical study of this valuable food crop the examination of the composition of the rices grown in Bihar and Orissa was undertaken, along with other related questions of interest.

It was thought desirable to confine the work to samples of rice in the Government farms, where they are grown under definite cultural conditions. The rices were, however, not pure line cultures. Of the samples received, three came from Bankipore, one from Bettiah, three from Cuttack, thirteen from Dumraon and five from Sabour. The samples studied did not include any *boro* rice.

Composition of the Rices. The composition of the rices did not vary much.

The analytical figures allow an interesting deduction. The amounts of oil, fibre and ash vary between very narrow limits and the sum of these constituents will be more or less constant. The sum total of the remaining constituents of albuminoids and soluble carbohydrates is thus also constant. It was found that the sum of the percentage figures for albuminoids and soluble carbohydrates, in all instances except three, fell between 94 and 95. In these three latter cases the figures were 93·9 and 95·3. But the deviation is so small that the general observation may be said to hold good in these instances also. It was thus noted that when

the amount of albuminoids was high the carbohydrate content was low and *vice versâ*.

The amount of phosphoric acid is always very slightly less than half of the total mineral matter present. Potash is, again, very nearly half of the amount of phosphoric acid present.

The effect of polishing. The composition of polished rice is dependent somewhat on that of the original unhusked rice. But although the amount of substance removed as bran is not very much, the grain suffers a material alteration in composition. The polished rice becomes poorer in all constituents except soluble carbohydrates which increase a little. The amount of oil decreases to less than half; the albuminoids suffer only a slight diminution; the fibre is reduced to about one-fourth of the original quantity and the amount of mineral constituents falls to a half. The outer layer and the embryo which are removed during the polishing operation are thus seen to be richer than the inner material in all these constituents. But the concentrations of fibre and oil in the bran are relatively higher than that of the mineral constituents. The distribution of the albuminoids is more uniform than that of any of the above.

It has been noted already that in the unpolished grain the quantity of phosphoric acid is just less than half of the ash. In the polished rice also, the phosphoric acid is slightly less than half of the amount of ash. The potash content, however, which in the unpolished rice is about half of that of the phosphoric acid now rises to about three-fourth of the amount of phosphoric acid.

It thus amounts to this that, although both phosphoric acid and potash are more concentrated in the " bran " than in the rest of the seed, the distribution of the potash is more uniform than that of the phosphoric acid.

As regards the material lost during the operation of polishing, this consists of the plant embryo and some of the outer layers of the grain. The germ being freely exposed and not embedded in the grain is easily rubbed off, the little

nick at one end of the polished grain marking the place where it was located.

Rice as an article of diet. It might be supposed that the estimation in which any variety of rice is held among the consumers, as evidenced by its market price, would be mainly determined by its nutritive value and its palatibility. The latter term includes culinary properties, such as flavour, consistence. appearance, taste, etc., which cannot be definitely described and are rather difficult to observe accurately.

As regards the nutritive value of rice, as revealed by analysis, there is no doubt that, other things being equal, the variety of rice which contains larger amounts of albuminoids is more valuable, inasmuch as albuminoids, which are the flesh formers, are a more expensive form of food than starch. The relative nutritive value of a sample of rice can thus be assumed to depend on its albuminoid content. It was noticed, however, that no accurate relation can be found between the chemical composition and the value of a rice from the consumer's point of view.

In a well-balanced ration, the relations between the albuminoids, the oil and the soluble carbohydrates should vary within certain definite limits. Rice, however, in common with other cereals, contains an excessive proportion of starch and is thus not suitable for use as the sole article of diet by any one.

This holds not only from the point of view of the organic constituents but also of the mineral ones, which are the bone-formers. Rice is quite poor in this respect also. The importance of giving due consideration to the amount and composition of the ash of foods is very great in order to ensure the supply of material for the proper development of bone, and of the mineral constituents necessary for vital processes—factors which have as much influence on the well-being of animals as proteids, carbohydrates and fats in appropriate quantities.

Where a variety of food stuff is used, the probability of much injury being done by ignoring these aspects of the

question is not very great. Happily the use of rice is nearly always supplemented by the addition of other substances of vegetable and animal origin which often supply the deficient elements.

An interesting characteristic of rice protein may be mentioned here. It has recently been shown that in its general aminoacid make-up the protein of rice more nearly resembles the majority of the proteins of animal tissues than do the proteins of maize and wheat. This may explain the fact that rice, in spite of its low protein content, furnishes food for more human beings than any other cereal.

The alteration in composition which rice undergoes during the process of polishing is of great significance from the medical point of view. Some authorities believe that beri-beri is due to specific germs. Others think that it is caused by the bacterial fermentation of the large amounts of carbohydrates eaten in unbalanced diet. But the consensus of opinion is that beri-beri is one of the " deficiency diseases " like, *e.g.*, scurvy or rickets. Most of the food articles in their raw state contain the curative substances. These are, however, at times lost, or considerably reduced, during the process of " finishing " and preparation which the fastidious taste of the modern consumer prescribes. Reduction in the content of phosphoric acid is now generally accepted as an index of the beri-beri-producing power of a sample of rice. Judged by this standard, although all samples of unhusked rice used during this investigation were good, many samples of the " polished " rice were unfit for consumption as a sole article of diet. It must be remembered, however, that rice is almost universally supplemented by some other foodstuffs, the mixed diet often to a great extent nullifying much of the apprehended injurious effects.

Assimilation of nutrients by the plant. The proper supply of nutritive elements is an important factor in the growth of a plant and, in view of the economic importance of the rice crop, a study was made of the assimilation of the nutrient materials by this plant at various stages of its growth.

For conducting these experiments a uniform plot of rice land was chosen at the Sabour Farm. The seed employed was " kalamdan " which is at present the standard medium aman paddy of the Sabour Farm. It was originally derived from pure culture and its purity was maintained, as far as is possible under field conditions, by rogueing every year.

In order to do away with the disturbing factors consequent on transplanting, it was decided to allow the rice to grow to maturity in the same field where it was sown. After the usual cultivations, the seeds were sown in the third week of May, by dibbling in plough furrows and afterwards covering them up by beaming. Weeding was done when required. The plot had to be irrigated once in August.

Samples of plants (the exact number of plants varying according to the size) were selected in such a way as to fairly represent the whole crop. It was not possible to take out the whole root system but care was taken not to lose much of the roots. After the soil adhering to the roots had been washed out the plants were divided into their botanical parts and analysed. The following samples were taken :— (1) very young seedlings, (2) at the transplantation stage, (3) at preflowering stage, (4) at the flowering stage (two samples, one in which the grain was in the " water " stage, and another in which it was beginning to form " milk "). (5) at the ripe or ordinary harvest stage and (6) when the crop was dead ripe. The results obtained need not be entered here in detail but some of the points observed may be mentioned.

1. The total dry matter in a rice plant increases up to the time of maturity, the largest increase in the weight of the crop occurring before the formation of the flowers.

2. The percentage of nitrogen generally exhibits a steady and continuous decrease from the first to the last period of growth, the most rapid decline being noted in the second period. The above-ground parts are always richer than the roots in their nitrogen content. At the ear-

lier stages the leaves are practically twice as rich in this element as the stems. As the ears form, both the stems and the leaves lose nitrogen. By the time that the grains " fill up " the nitrogen accumulates most in the grain while in the other parts of the plant it falls to the uniform level of about a third of what is present in the grains. It seems therefore that there is a tendency for the nitrogenous matter to press forward towards the top of the plant.

3. The configuration of the curve of the content of phosphoric acid at the different stages indicates that the amount of this plant food available for the rice plant at Sabour was low throughout.

4. The percentage of potash in the above-ground parts increases from the first stage to the preflowering stage from whenceforward there is a decline. In the roots also there is a continued fall after the second stage.

5. As the ears form and mature there occurs a concentration of nitrogen, phosphoric acid and potash in the grains at the expense of the other parts of the plant.

6. The assimilation of nitrogen, phosphoric acid and potash by the plant is fairly complete by the time flowers appear. Hence enough plant foods must be available for the plant during the early stages.

7. There does not seem to be any migration of the absorbed nitrogen and potash back into the soil.

8. Taking the yield of a crop of rice as 900 lb. of dry grain, the soil suffers a depletion of 29·33 lb. nitrogen, 9·64 lb. phosphoric acid and 49·69 lb. potash per acre by the removal of the grains and straw.

Feeding value of the different parts. As to the feeding values of the different parts of the rice plant, as calculated from the chemical analysis at the various stages, it was found that the straw declines in value with the age of the plant but there is no difference in nutritive value between ripe and dead ripe plants. The leaves are more nutritious than the stems of the same period. The leaves in the preflowering and the flowering stages are about

equally nutritious but decline considerably in value as the plant matures.

VI. Feeding Stuffs (General).

A considerable number of samples of feeding stuffs have been analysed, the greatest number being, as in last year, from the Military Department. It is intended to issue a bulletin incorporating the results of these and other analyses.

VII. Starch.

The experiments begun last year in connection with sweet potato as a possible source for the commercial production of starch, have been continued.

In order to find out the yield and quality of starch at different periods of growth, fortnightly harvests were made from a field of sweet potatoes, from the latter half of January to the end of March. The analysis showed that the best time for harvesting the crop was the middle of February.

Through the kindness of the Imperial Agriculturist arrangements are being made to grow different varieties of sweet potato in a plot of land better suited to this crop.

Another crop tested was the kidney-shaped yam, *Dioscorea fasciculata* (vern. *suthni*) which also is largely grown here. One sample was found to contain 19 per cent. of starch, and to yield a very good quality of starch.

VIII. Lathyrus sativus.

An attempt was made to find out the poisonous constituent of *Lathyrus sativus* (vern. *khesari*) which has a bad reputation for causing paralysis. Samples of this pulse grown at Pusa and at Barail (a village 8 miles from Pusa which is notorious for cases of lathyrism) as well as some samples from the Central Provinces (where also bad cases of the disease occur) were examined. No alkaloids were detected although some of the previous workers had found what seemed to be a volatile alkaloid.

During the course of this work it was found that *khesari* samples are very often contaminated with foreign seeds from which a cyanogenetic glucoside was isolated and some feeding experiments were conducted with guinea pigs. These seeds were identified as *Vicia sativa* (vern. *akta*) and *Vicia hirsuta* (vern. *misia*). As the chemistry of these grains had been worked out by Ritthausen, further investigation was abandoned.

IX. Relation of Transpiration Ratio and absorption of food materials.

Pot culture experiments were started during the year to ascertain the relation between the transpiration of water and the assimilation of plant food at different stages of the plant's growth. The following crops were sown :—Maize, velvet bean, *rahar* and *marua* in the *kharif* and *sarson*, wheat and gram in the *rabi*.

The soil employed was Pusa soil and received an application of superphosphate and potassium nitrate. The moisture content of the soil was maintained at 20 per cent. and the transpiration was daily measured. At regular intervals the plants from the jars were harvested and analysed for nitrogen, phosphoric acid and potash.

Some interesting results have been obtained but results of further experiments are awaited before definite conclusions could be justified.

X. Programme of work for 1916-17.

Major subjects :—

1. Records of the amount and nature of drainage water from fallow land, and land bearing crops, will be maintained.

2. The relation between the transpiration of water by plant and the assimilation of plant material during the period of growth will be further studied.

3. An examination of the proportion of starch in some of the Indian starch-producing crops will be made with a

view to their possible utility as commercial sources for the manufacture of starch.

Minor subjects :—

1. The assimilation of plant material by the rice plant will be further studied.

2. The problem of the occurrence of infertility under trees will be examined.

XI. Publications.

The following papers were published during the year :—

(1) Leather, J. W. . Soil Temperatures. *Mem. Dept. of Agri., India (Chemical Series)*, Vol. IV, No. 2.

(2) Leather, J. W. . Soil Gases. *Mem. Dept. of Agri., India (Chemical Series)*, Vol. IV, No. 3.

(3) Leather, J. W. . The Detection of Added Water in Milk in India. *Bulletin 57, Agricultural Research Institute, Pusa.*

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REPORT OF THE IMPERIAL ECONOMIC BOTANISTS.

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I. Introduction.

The Imperial Economic Botanist held charge of the section during the year with the exception of one month (November 10th—December 9th, 1915), when privilege leave was taken in India. The Second Assistant was in charge of current duties at Pusa during this period and the Third Assistant was placed in similar charge at Quetta. Both of these assistants acted up to the level of their responsibilities.

The work of the staff during the year was quite satisfactory. Babu Kashi Ram was appointed to the post of Fourth Assistant on transfer from the Saharanpur Botanical Gardens and has made a good beginning in his work. This opportunity is taken of acknowledging the valuable assistance given by Mr. Hartless, the Superintendent of the Saharanpur Gardens, in training men for work in the Botanical Section at Pusa and also at the Fruit Experiment Station at Quetta. Babu Chandu Lall has improved in his work at Quetta and has been confirmed and promoted by the Baluchistan Administration.

One student from Burma worked in the section during the cold weather.

Mr. Jatindra Nath Sen, officiating Imperial Agricultural Chemist, has carried out a good many analyses for the section which have proved of considerable use in our investigations.

II. Investigations at Pusa.

Wheat.

Pusa 12. While a beginning has been made in several Provinces in distributing this wheat to cultivators, these efforts are of minor importance compared with the schemes

in progress in the United Provinces where the Agricultural Department, during the past year, has made considerable progress in the systematic replacement of the country wheats by this improved type. The trial of Pusa 12 in these Provinces has passed the experimental stage and the time is rapidly approaching when it will be possible to see large continuous blocks of this variety true to type. At first, progress was greatly hampered by a shortage of seed but with an increasing supply and with larger funds for financing the operations, these preliminary difficulties are being overcome. A feature of the work of seed distribution in the United Provinces is the manner in which all the existing agencies have been utilized. In the Central Circle, the Co-operative movement has largely been employed in addition to Court of Wards' estates and large zamindars. In Oudh, an entirely new agency has been brought into use by Mr. Sharma, namely, the local notables, who, in a sense, are large and wealthy Co-operative Societies ready-made commanding great influence with the cultivators. Anyone who has seen the work in progress with Pusa 12 on some of the large private estates in Oudh cannot fail to be impressed by the immense possibilities of this new departure. Improved agriculture on these estates has been found to be very profitable and the new private seed farms, such as those personally conducted by the Raja of Amethi and the Kunwar Sahib, are proving of great value to the Agricultural Department in the replacement of the local wheats by Pusa 12.

Like the season of 1913-14, the year in the United Provinces was characterized by a shortage of moisture, particularly in the Western Districts. Pusa 12 again withstood satisfactorily these adverse conditions and its behaviour, as compared with the country wheats, was summed up as follows by the Director of Agriculture in "United Provinces Agricultural Notes" for March and April 1916 :—

"Pusa 12 wheat has again proved markedly superior to the Provincial wheats, and is likely to go ahead rapidly over the western and central portions of the provinces.

Apart from its qualities of yield, it requires less water than the best local varieties, such as Muzaffarnagar, and is likely to take the place of the latter in the canal tracts owing to recurrent shortages of the water. In one of the private estates in Oudh in which there are 75 acres under this wheat, the crop, which is being threshed out by the Department, has given an average of 25 maunds of grain and 45 of *bhusa* per acre." (*Pioneer*, April 9th, 1916.)

" Figures have been received from Co-operative Societies as to the relative yield of Pusa 12 and *deshi* wheat. In two neighbouring societies, in the Central Circle, the average yield of Pusa 12 was 19 maunds per acre and of *deshi* $16\frac{1}{4}$ maunds. The former wheat stood the test of a dry season satisfactorily. Crop cutting experiments were carried out in fields where only one irrigation was possible; and the yield of Pusa wheat was 17 maunds as compared to $14\frac{1}{4}$ from *deshi*. On an average, the former wheat yielded substantially more *bhusa*." (*Pioneer*, April 8th, 1916.)

These results enable a rough estimate to be formed of the annual increase in value of the crop which will be obtained when the whole of the wheat-growing area of the United Provinces is replaced by Pusa 12 or some similar improved type. As far as yield of grain and *bhusa* are concerned, the increased production due to Pusa 12 comes to over twelve rupees an acre. If the improved grain quality is estimated at three annas a maund and if the average production is put at sixteen maunds to the acre, the increase in the value of the crop from this cause would be three rupees an acre. Considering that Pusa 12 already commands a premium of more than four annas a maund in the local bazaar, the above estimate is well within the truth. If, therefore, we take into consideration both yield and quality, the substitution of the country wheats by Pusa 12 means an immediate average increase of fifteen rupees an acre or £7,000,000 per annum for the whole of the United Provinces.

While the local transactions in Indian wheat are considerably more important than the export trade, neverthe-

less the latter is well worthy of consideration even under the present conditions of production. If, however, an increase in yield is brought about by changing the variety or by better methods of cultivation, the surplus left over for export will increase and India will then take a larger share in the wheat production of the Empire. There can be little doubt that such a result is easily possible. At present, the great plains of India do not produce half of what is possible. With a few simple improvements, the alluvial soils of India could be made to grow twice their present crops and the Punjab and the United Provinces would then become the most important bread-basket of the Empire. Wheat-growing is at present one of the great neglected and undeveloped natural industries of India. The capital for expansion is lying ready to hand in the shape of a marvellously fertile soil when properly managed, while in the cultivator and in his oxen is the foundation of the labour force necessary for development.

In consequence of the extension of indigo cultivation in Bihar, the area of Pusa 12 put down for seed on the estates was considerably restricted. In spite of the high prices of indigo, over 3,000 maunds of seed of this type were supplied to Mr. Burt for distribution in the United Provinces.

Pusa 4. The circumstances of soil and climate in some of the wheat-growing tracts of India are such that a rapidly maturing variety is one of the conditions of progress. In tracts like Bundelkhand, some of the Central India States, the southern portions of the Bombay Presidency and parts of Bihar, a wheat is required which can ripen quickly with a short supply of moisture and which can also resist the early rusts. In such tracts, deep-rooting, high-yielding kinds are useless and producing power has to give place to the insurance of the yield in years of average soil moisture. In such areas, Pusa 4 is giving good results and is being taken up by the cultivators. The demand for seed is increasing and for several years to come the surplus produce from the indigo estates in Bihar is likely to continue to find a ready market. Pusa 4 is a large-grained, attractive-looking wheat which at once finds favour with the cultiva-

tors and in the bazaar on account of its grain quality and the high percentage of flour it yields.

During the year, a complete milling and baking test of this variety was carried out at the Hooghly Flour Mills, Calcutta, managed by Messrs. Shaw, Wallace & Co. The sample milled was 350 maunds in weight and was grown as a cover crop for Java indigo on the Dholi and Benipore estates in Bihar. The report, which will be published in due course, is an exceedingly favourable one. The wheat behaved in the mill exactly as would be expected from Mr. Humphries' reports on maund samples in England while the loaves were much superior to those produced from the best Calcutta flour.

Pusa 4 is doing very well in New South Wales. A large sample, grown at Gilgandra from seed supplied from Pusa, took the first prize at the recent Royal Agricultural Show at Sydney. This prize has formerly been obtained by one or other of the wheats produced by the late Mr. William Farrer. Both in appearance, bushel weight and in the milling tests, Pusa 4 proved superior to any of the new varieties produced in New South Wales.

The demand for seed of Pusa 4 increased considerably during the past year. In addition to numerous small consignments, about 1,500 maunds were supplied from Bihar estates to Mr. Burt, in connection with his seed distribution scheme in Bundelkhand. As usual, a large number of indents were received after the available supply had been disposed of. There seems to be an exaggerated idea in India as to the resources of the Botanical Section at Pusa both as regards storehouse accommodation and as regards funds. Neither Pusa nor the Bihar indigo estates, which grow wheat for seed, are in a position financially to warehouse large quantities of seed wheat during the monsoon. All wheat, except for seed, has to be distributed at harvest time, a fact which correspondents should carefully bear in mind.

Shipments of Pusa 12 and Pusa 4 to England. In the last annual report, mention was made of a small prelimi-

nary shipment of Pusa 12 to England. This side of the wheat investigations, which is being conducted in co-operation with Mr. B. C. Burt, Deputy Director of Agriculture, Central Circle, United Provinces, has developed rapidly during the past wheat-growing season. The parcel sent to England in 1915 was only 810 maunds, which after several delays, due to congestion at the port of London after the outbreak of the war, eventually reached the mill. It was made into flour by Mr. A. E. Humphries and distributed to the leading millers in England. The reports received were very favourable and larger samples were asked for. This year, over 5,000 maunds of Pusa 12 were collected by Mr. Burt for export which have been shipped to England by Messrs. Ralli Brothers who, as in previous years, are doing everything possible in bringing the new variety to the notice of the trade in Great Britain. As soon as the milling reports are received, a full account of this part of the work will be published.

In addition to Pusa 12, requests were received from the English millers for samples of Pusa 4 large enough for a full milling test. This request was complied with and about 4,000 maunds of this variety have been shipped by Messrs. Ralli Brothers to London, Liverpool and Hull. Three quarters of this parcel was grown in Bihar on the Dholi, Belsund and Hathowrie estates while the remaining 1,000 maunds came from some of Mr. Burt's wheat centres in Bundelkhand.

Other wheat investigations. In addition to the work relating to seed-distribution and to the establishment of new grades of wheat in India, a large amount of time continues to be devoted to the various wheat investigations in progress at Pusa.

Four series of exceedingly promising new crosses are being worked out in detail. In all these an effort is being made to combine rust-resistance, standing-power, grain quality and yield in the same type. It is expected to evolve from these new forms a set of wheats which will replace all those now under cultivation and also make the most of

India's possibilities as a future producer of wheat. Before they can be distributed to advantage, however, much remains to be done in improving wheat-growing including the control of irrigation water and the proper management of alluvial soils. At present, only a few inches of the surface soil of the great plains are being utilized by the wheat crop and the cultivation of deep-rooting, high-yielding kinds is out of the question. When the need for surface drainage is understood and when the importance of soil-aeration is realized, the wheat crop will be able to make use of a much thicker layer of the alluvium than is now possible. The proper use of green-manure will also increase the rapidity of growth. When these improvements have been adopted, the way will be open for the successful introduction of the new wheats now being made at Pusa.

Tobacco.

Evidence of the popularity of Type 28 for cigarettes and its suitability for widely different soils and climates continue to increase. The Bihar ryots who are growing leaf for the various branches of the Indian Leaf Tobacco Development Company, are demanding the seed of this type in larger and larger quantities, the distribution being carried out by the Dalsing Serai Branch. In Burma, Mr. McKerral reports that Type 28 is doing well for cigarette purposes and that a scheme of seed-distribution is under consideration. In the United Provinces, Mr. Burt has obtained good results with this variety and seed distribution in two Districts is contemplated. Some time ago, very good crops were obtained in the Central Provinces by Mr. Clouston. To meet the increasing demand for seed, nearly half an acre was allowed to flower last season and measures were taken to prevent cross-fertilization. If still larger quantities of protected seed are asked for, the expense involved will be considerable and it may be necessary to ask Government to increase the annual grant for this section.

At the present time in Bihar, the chief direction of progress in tobacco growing is the discovery of some means of lowering the cost of production of this crop. The two chief items in this expenditure are, firstly, the labour involved in the management of the monsoon fallow which precedes tobacco and, secondly, the cost of the manure required. Both these matters have received attention in the Botanical Section. The cost of the monsoon fallow has been reduced by the introduction of the five-tine spring-tooth cultivator by which the efficiency of the plough cattle has been increased threefold and by which it has been possible to keep these fallows clean even in wet years. With regard to the cost of manuring, a method has now been discovered by which heavy, well-ripened crops of leaf can be obtained with green-manure alone. The successful use of *sanai* (*Crotalaria juncea*) as a green-manure for tobacco in Bihar has been found to be a matter of soil-aeration. In the decay of the green crop, a vast amount of oxygen is required and a corresponding volume of carbon dioxide is produced in the soil. For this decay to take place with the necessary rapidity under monsoon conditions, it has been found necessary to promote aeration by suitable surface drainage and by the provision of a certain amount of broken tile (*thikra*) in the surface soil. Under such conditions, the tobacco crop does not suffer from want of air during growth and the ripening processes are not delayed as is the case in green-manuring in the ordinary way. Proceeding in this manner, namely, by green-manuring on drained land containing *thikra*, a crop of cured cigarette tobacco weighing 24 maunds to the acre was produced, which was sold to the Indian Leaf Tobacco Development Company at Dalsing Serai for fifteen rupees a maund. The product was cured on the ground in the country fashion, care being taken to use the minimum amount of moisture in the process. The application of this method under estate conditions is naturally a question of the capital involved in the addition of the necessary amount of *thikra* to the soil. An area of land is now under treatment on the Dholi estate and it is

proposed to publish from time to time the value of the annual produce so that this can be compared with the capital involved in the improvement. There is no doubt of the effect of *thikra* in increasing the value of green-manure. The question that remains for decision is whether the improvement will pay under present conditions. It is expected that the Dholi results will answer this question.

Indigo.

In the last annual report, a detailed account was given of the results of our study of the wilt disease of Java indigo and of the importance of soil-aeration in the development of the roots and root-nodules of this crop. The question of the production, on the Bihar estates, of the seed of Java indigo was also dealt with and the conditions necessary for success were outlined. The general experience of the past indigo season supplied an interesting confirmation of the views put forward in the first and second reports on the improvement of indigo. The monsoon of 1915 in North Bihar was heavy and well-distributed and, in addition to the rainfall, there occurred a series of floods which on most estates cut short indigo manufacture and killed out large areas of the crop. The weather during the first half of August—the period when Java indigo has to be sown for seed—was very wet and few breaks occurred. The almost continuous rainfall after the seed crop was sown, coming as a re-inforcement to the heavy falls in July and the floods, so consolidated the soil and interfered with its aeration that on a comparatively few estates only did the seed crop do well. It was only in cases where the surface drainage was good and the natural aeration of the soil was above the average that Java indigo sown for seed was able to grow normally and produce an average outturn. On the heavier soils in the submontane tract and on the lighter lands which had been flooded previous to sowing, the soil-aeration was so interfered with that the seed crop was attacked by *Psylla* and proved a complete failure. On some of the drained plots at Pusa, the seed crop was distinctly

yellow after the late October flood and a good deal of leaf was lost while the sub-soil was drying during November and December. During the cold weather, the aeration improved and the foliage then became normal both as regards colour and extent.

In the case of Java indigo sown for leaf in early October on the higher lands, quite different results were obtained. After sowing time, little or no rain fell till March and so there was nothing to interfere with the natural aeration of the soil. In many cases, this leaf crop gave small crops of excellent seed, a phenomenon which does not often occur in years when the normal amount of cold weather rainfall is received.

This experience agrees in all respects with the results of the various experiments in growing Java indigo for seed at Pusa. Seed formation, other things being equal, is a matter of soil-aeration. If ample air for the roots of Java indigo is provided, a full crop of seed is obtained. Just as surely heavy and long-continued rain after sowing destroys all hope of a normal yield of seed even when the crop recovers slowly during November and December. In all such cases, the season is missed and flowering begins too late after the cold season has set in and the bees have finished their labours.

As seasons like that of 1915 are to be expected every now and then in Bihar, experiments have been started to determine whether it will pay to treat some of the higher lands on the indigo estates with *thikra* so as to increase the aeration in wet years. These are in progress both at Pusa and at Dholi and the results will be published in due course. At the same time, experiments are in progress to see how far suitable methods of cultivation of the young seed crop will remedy the effects of heavy rain after sowing.

Gram.

An account of the preliminary work on gram was published during the year in the *Memoirs of the Department*

of Agriculture in India. A number of types have been isolated which are being tested for yield under various conditions. A few of these have been distributed for preliminary trials outside Pusa.

As pointed out in the last annual report, the yield of gram like that of indigo depends on the aeration of the roots and nodules. If, however, this crop is grown on well ventilated soils which are also rich in combined nitrogen, the yield of seed always falls off although the amount of growth is enormous. When the crop obtains a large amount of nitrate in solution from the soil and also forms nodules, it is overstimulated and readily becomes too rank. The heaviest and best-ripened gram is always grown at Pusa on well-aerated plots which are distinctly poor in available nitrogen. In the past season, the best crop of gram was obtained by late sowing on a *thikra* plot immediately after the removal of a heavy crop of *patwa* (*Hibiscus cannabinus*). Java indigo grown for seed sometimes behaves in a very similar manner and experiments on this point are now in progress.

Oil-seeds.

The work so far done on safflower (*Carthamus tinctorius*, L.) and *rai* (*Brassica juncea*, H. F. and T.) has just been published in the Botanical Memoirs.

The study of Indian linseed has been begun and an attempt is being made to produce a large seeded linseed for the plains. At present, the types grown on the alluvium have very small seed, the large seeded forms being produced on the soils of Central India. These two classes of varieties are otherwise quite different—those from Central India with large seeds having a deep root system to suit the black soils while those of the plains are surface rooted. Crosses are being made between these types with the object of producing for the alluvium new surface-rooted kinds with large bold seeds. In addition to the inheritance of size of seeds, this study ought to provide interesting results on the genetics of root-development.

Soil-aeration.

The preliminary results obtained on the aeration of soils in India were published during 1915 as Bulletin 52 of the Pusa Institute. A considerable amount of interest has been aroused by this publication of which a second edition was called for during the year. This paper was reviewed very favourably in *Nature* of February 24th, 1916, and has been well received in Europe. A paper on soil-aeration was read at the Indian Science Congress at Lucknow in January last when Mr. Hole, the Imperial Forest Botanist, also gave an account of his work on aeration from the point of view of Indian Forestry. Both these papers attracted a good deal of attention and were keenly discussed.

The views put forward on this subject in Bulletin 52 were amplified and developed in a lecture given to the Board of Agriculture at Pusa last February. This lecture has been passed for printing and will shortly appear as Bulletin 61 of the Pusa Institute. In this paper, the connection between soil-aeration and the development of quality has been outlined and considerable space has been devoted to the practical applications of soil-ventilation including the saving of irrigation water and the increase in crop-production in the plains of India.

Surface drainage.

As in the case of soil-aeration, the publication of Pusa Bulletin 53 on soil-erosion and surface drainage has led to such a large demand for copies that a second edition of this paper had to be arranged within a year of the appearance of the first. This bulletin was written largely as an introduction to the discussion on these subjects which took place at the last meeting of the Board of Agriculture. The views put forward in this paper were accepted by the Board and three resolutions, largely based thereon, were recommended to the consideration of the Government of India.

Interest continues to be taken in the Pusa system of surface drainage which is to be seen at Dholi on an estate

scale. A large number of visitors saw this estate during the year and this method of drainage is now being taken up in Bihar. His Highness the Maharajah of Darbhanga is showing a personal interest in this matter and a beginning has been made on several of his estates. In this work Mr. R. S. King, Sub-Manager of the Jhanjharpur Circle of the Raj, is taking the keenest interest both in local drainage schemes on the Darbhanga properties and also in the scheme for the preparation of a contour survey of North Bihar. In the United Provinces, the Pusa method of drainage has been adopted at two centres and results similar to those in Bihar have been obtained.

Perhaps the most notable advance in drainage in Bihar during the year is the fact that the Commissioner and the District Embankment Committees of the Tirhoot Division are taking up the question of the general drainage of Bihar on the basis of a drainage map, constructed on the lines of the system introduced by the late Sir Edward Buck. A joint meeting of the District Embankment Committees of the Division was held at Muzaffarpur in December 1915 when the general lines of future work on this subject were discussed.

III. The Development of the Agriculture of Baluchistan.

Although started for local objects, the foundation of the Fruit Experiment Station at Quetta has led to the discovery of results of considerable importance to Indian Agriculture. These apply particularly to the irrigated tracts of India and are concerned with the saving of water in wheat-growing and with improved methods of growing fodder crops.

Water-saving.

The earlier results on water-saving in wheat-growing were published during the year in Bulletin No. 4 of the Quetta series. In this paper, the opportunity was taken of stating very briefly the main principles on which the right use of irrigation water depends. A careful com-

parison of these principles with the practices in vogue in the irrigated areas of Baluchistan cannot fail to show that an enormous quantity of valuable water is now being wasted. As the principles underlying water-saving are not understood and little has been done in utilizing the present supplies to the best advantage, it will not be out of place briefly to refer to them here. Both experience and experiment prove that if the maximum duty of irrigation water in wheat-growing is to be obtained, special attention must be paid to the following five principles :—

1. The irrigation water available must be spread over the largest possible area.

2. Heavy waterings reduce the proportion of grain to total crop.

3. The growth period of wheat is increased by heavy waterings.

4. When the water supply is limited, the root development of the wheat crop must be deep.

5. The soil moisture must be preserved, as far as possible, by a surface mulch of dry soil.

Applying these principles to the conditions of the Quetta valley, it was found that the highest duty of water could be obtained by irrigating the land once a few days before sowing and by breaking up, by means of the lever harrow, the rain crusts formed during winter and spring. The average yield on large scale trials on unmanured land at the Experiment Station worked out at $17\frac{3}{4}$ maunds of grain per acre. The zamindars, on the other hand, often water their wheat six times after sowing and obtain an average of $13\frac{1}{2}$ maunds of grain. The same amount of water spread over seven acres, if used according to the method employed at the Experiment Station, would give 7 times $17\frac{3}{4}$ or $124\frac{1}{4}$ maunds of wheat. The difference in favour of the experiments is therefore $110\frac{3}{4}$ maunds of wheat. If the average irrigated acreage of wheat in the Quetta valley is multiplied by 100, the result would indicate, in maunds of wheat per annum, the present annual waste of water on this crop alone. On every 200 acres of

irrigated wheat, the water now lost would produce 20,000 maunds of grain and a large amount of straw of a total value not far short of a lakh of rupees.

During the past wheat season, the new methods have been tried on zamindars' land near Quetta. One watering was given at the end of September before sowing and in spite of the fact that the winter rains did not set in till late in January, two months later than usual, a very good crop resulted, the grain of which was well above the average in quality. The yield of grain was 22 maunds 32 seers per acre, while the *bhusa* amounted to 43 maunds 20 seers. This result, in spite of the lateness of the winter rains, is five maunds higher than the average obtained at the Experiment Station. This is due to the fact that the wheat land at the Experiment Station is high-lying, exposed to the sun and wind and its water-holding capacity is less than that of the typical wheat lands of the valley. The Experiment Station yields have therefore been exceeded by the zamindars in a season of badly distributed rainfall when the local dry-crop wheat was a failure.

These results have naturally attracted a considerable amount of attention. On May 29th, a meeting of the *maliks* of the valley was arranged at the demonstration area when the Agent to the Governor-General and the chief officials of the Baluchistan Administration were present. On June 5th, the Political Agent brought the *maliks* of the Pishin valley to see the results. These visits were entirely successful, a keen interest was shown by those present and large areas of land were at once offered for demonstration work for the next season's wheat crop. Sir John Ramsay has ordered 25 pairs of lever harrows, some of which will be given as *khillats* at the September *Darbar*. The irrigation policy of the Administration has recently been revised, partly as a result of these experiments and particular attention will, in future, be paid to water-saving and to the increase in the duty of the present supplies.

The investigations on water-saving are being continued and during the year further results were obtained, an

account of which is now being prepared for publication. These refer to the improvement of water channels, to the most suitable form of *kiari*, to the proper slope for flood irrigation and to the control of the water while being applied to the land.

The improvement of fodder production.

In addition to the saving of irrigation water, there is another direction in which the productive power of the land in Baluchistan can be increased. This is in the provision of a fresh source of organic matter for supplementing the present supplies of farm-yard manure. The addition of organic matter to the soils of the Quetta valley does much to increase their porosity and water-holding capacity and also to mitigate the evil effects of surface-flooding. The growth of Persian clover (*Trifolium resupinatum*), locally known as *shaftal*, has been found to improve the cropping power of the land very considerably and to be a valuable source of organic matter, particularly if the last crop is ploughed in as a green-manure. It also supplies a large quantity of valuable fodder and is a simple means of utilizing the winter rains.

Some attention has been paid to increasing the yield of *shaftal* and other crops at Quetta, and to the best means of improving the duty of water in fodder growing. Such crops grow faster and need less water, if the land is manured in the first instance with farm-yard manure at the rate of 15 to 20 tons per acre. The proper grading of the surface and the use of long *kiaris* (about $300' \times 25'$) watered from one end of the field leads to an even flow of the irrigation water over the land and to uniform percolation. In this way, a great saving of water takes place. The expense and trouble of the preliminary grading and levelling and of the adoption of the most suitable form of *kiari* are well repaid by the amount of water saved, by the ease with which irrigation can be carried out and by the evenness of the resulting crop.

During the past season, one of the plots at Quetta, which was not in very good condition, was put down in

shaftal in August 1915. The land was manured with farm-yard manure at the rate of about 20 tons per acre and sown with *shaftal* under a thin cover-crop of maize. Six cuts of clover were obtained by the middle of June 1916, the total weight of which was over 33 tons per acre. At eight annas per 100 lb., the year's produce is worth Rs. 371 per acre—an income obtained with the minimum expenditure of water and resulting in an increased fertility of the land. This result, which has been confirmed many times at Quetta, indicates the methods which should be adopted in fodder growing in India—intensive cultivation with the minimum expenditure of irrigation water.

While *shaftal* has proved a useful green fodder, particularly for dairy cows and buffaloes, its best use to Baluchistan is in the form of clover hay, put up in bales suitable for storage and for easy transport on mules or camels. Real hay is unknown in India, its place being taken by in-nutritious substances like dried grass and *bhusa*. A considerable amount of attention has therefore been paid to the drying and baling of *shaftal* and to the preparation of real hay. In European countries, the difficulties in hay-making are concerned largely with the slow rate of drying and with the interference caused by frequent showers. At Quetta, the problem is reversed. The air is so dry and the sun is so strong that the hay easily becomes overdried and so brittle that it is broken to powder when handled. Baling such a product is out of the question and even if it could be stacked, no mild after-fermentation could take place. These difficulties are overcome by drying in stages in heaps on the field and by preserving sufficient natural moisture for a slight fermentation to take place in the stack before baling. Early last year, trials of the new baled fodder were carried out with the horses of the 72nd Heavy Battery at Quetta under the Commandant, Colonel H. M. Courtenay, R.A., who reported very favourably on the results. The transfer of this unit and the death of the Commandant on active service put an end to the trials. They have, however, been continued by Brigadier-General

Cook, R.G.A., with one of the mule teams of the 4th Mountain Battery. The trial has been a great success and the mules did better on *shaftal* hay than on their ordinary ration of *bhusa* and grain. The saving in weight was about 30 per cent. and the cost was also substantially reduced. There is now little doubt that the use of baled *shaftal* as fodder for Army purposes would mean a reduction in the weight of forage of some 30 per cent., a point of considerable importance on the Frontier where the difficulties of transport are so great.

Shaftal and lucerne are by no means the only leguminous plants in North-West India, that could be made into hay and pressed into bales. There should be no difficulty in drying and pressing crops like *berseem* and *senji* which are already cultivated in Sind and the Punjab respectively. The albuminoid ratio of such fodders is much above that of *bhusa* and there is a great opening for such produce both in the Army and also in the cities and on the main roads of North-Western India. Later it might spread to the cultivators and for the building up of fodder reserves for use in time of famine. Once such fodders as *shaftal* hay find their way into Indian agriculture, the efficiency of the ox, on which the system rests, will increase and at the same time the producing power of the land will improve.

Besides their local significance, these results on water-saving and fodder-growing have a distinct bearing on the development of Indian Agriculture. To anyone who can read his practice in the plant, there can be no doubt that in the irrigated tracts of the country, a great waste of valuable irrigation water is going on which is not only lost but also damages the standing crops and tends to lower the general fertility of the country. There are many tracts in India where a perennial system of irrigation is scarcely suitable and where the duty of water might be increased by working on older lines and by substituting in its place a modified form of inundation. The problem of using the present supplies of water in India in wheat-growing is largely physiological and depends for its solution on a knowledge

of the functions of the plant. Crops like wheat require a well aerated soil as well as a sufficient supply of moisture. The continual surface flooding which takes place in a perennial system of irrigation destroys the natural texture of the soil and interferes with its aeration. The addition of more water to a crop in which the yield is already limited by want of air cannot possibly produce any useful result. Particularly is this the case on the fine alluvial soils of the plains and on the black soils of the Peninsula. The problem of obtaining the maximum duty of water is to supply moisture without depriving the soil of air. In many cases, this can be accomplished by a single irrigation before sowing followed by moisture conservation methods like those adopted at Quetta. In other cases, the amount of water can be reduced by increasing the water-holding capacity of the soil by green-manure and by other methods now being worked out. Any saving of irrigation water in India is an advantage both to the people and to Government. The less water used the less is the damage done to the country and the larger is the area irrigated. Government benefits by a growing revenue and by increased opportunities for the settlement of discharged sepoys and of the surplus population of congested districts. Under the present system of perennial irrigation, India is rapidly reaching the limit of profitable expansion with the water now available. Any great extension must be achieved by increasing the duty of water, a problem full of possibilities for the country but one on which hardly any attention has yet been bestowed.

Fruit investigations.

It is proposed to defer till the next annual report any detailed account of the results which are now rapidly accumulating with regard to the cultivation and propagation of fruit trees and to the transport of the fruit itself. Many of the problems relating to these matters are on the point of solution and in another year the subject can, in all probability, be dealt with much more definitely and satisfactorily than at this moment.

Improved fruit boxes. As far as the design of suitable fruit boxes for the Quetta trade is concerned, this portion of the work may be said to be completed. The only thing that remains is the discovery of the cheapest and most satisfactory source of the box boards and cardboard. A large amount of time has been spent in trying to discover whether the box boards could not be obtained in India itself. After numerous enquiries, an Indian firm was discovered whose tenders were satisfactory. The execution of the orders, however, left much to be desired and when enquiries were made as to future supplies of a more satisfactory character an attempt was made to increase the price far beyond the value of the material. For the present, it has been found more satisfactory to import the boards from Great Britain in spite of the increase in cost due to the war and to the rise in freights.

The demand for the improved boxes showed a most satisfactory increase during the summer of 1915, and about 3,176 boxes and 2,200 two pound punnets were sold. For many of these packages the demand was greater than the supply and the entire stock was sold long before the end of the season. For 1916, a much larger supply has been procured, more than sufficient for any possible demand that is likely to arise.

The new cardboard boxes have proved a great success and are in active demand. These can be used as returnables and last for three or four journeys to and from Quetta. In this way, the expense is reduced and the cost of the package each journey for five seers of choice peaches comes to less than four annas. Another advantage of these cardboard boxes is that they are thief-proof and cannot be tampered with in transit without immediate detection.

One indirect result of the new boxes should be mentioned, namely, the stimulus they have given to new planting. A great demand for nursery stock has arisen and many large fruit gardens are being put down. To meet this, the number of trees issued by the Fruit Experiment

Station is being rapidly increased and by the end of 1917, it is expected that all possible requirements can be met.

IV. Programme and publications.

Programme of work for 1916-17.

Work will be continued on the following crops on the lines indicated in the annual reports and in the publications of the section—wheat, tobacco, gram, fibre plants, indigo, oil-seeds, fodder crops and fruit.

Publications.

The following papers were published during the year. In order to bring the list up to date and to make it correspond with this report, all papers in the press which are due to appear before the end of July 1916, have been included. The Urdu editions of three of the Quetta Bulletins were prepared by members of the staff of this section :—

1. Soil aeration in Agriculture. *Bulletin 61, Agricultural Research Institute, Pusa*, 1916.
2. Soil ventilation. *Bulletin 52, Agricultural Research Institute, Pusa*, Second Edition, 1916.
3. Soil Erosion and Surface drainage. *Bulletin 53, Agricultural Research Institute, Pusa*, Second Edition, 1916.
4. Report on Agricultural Botany for 1914-15, for the Board of Scientific Advice.
5. The importance of soil ventilation on the alluvium. A paper read at the Indian Science Congress, Lucknow, 1916, and published in the special Congress number of the *Agricultural Journal of India*, 1916.
6. The Application of Botanical Science to Agriculture. A paper read at the Indian Science Congress, Lucknow, 1916, and published in the special Congress number of the *Agricultural Journal of India*, 1916.
7. The manurial value of potsherds. *Agricultural Journal of India*, Vol. XI, Part 3, 1916.
8. Some improvements in the packing and transport of fruit in India. *Bulletin 2, Fruit Experiment Station, Quetta*, Second Edition, revised, 1915.

9. Soil ventilation. *Bulletin 3, Fruit Experiment Station, Quetta,* 1915.
10. The saving of irrigation water in wheat-growing. *Bulletin 4, Fruit Experiment Station, Quetta,* 1915. Reprinted in the *Agricultural Journal of India,* Vol. XI, Part 1, 1916.
11. Clover and Clover Hay. *Bulletin 5, Fruit Experiment Station, Quetta,* 1915. Reprinted in the *Agricultural Journal of India,* Vol. XI, Part 1, 1916.
12. An improved fibre plant. *Agricultural Journal of India,* Vol. X, Part 3, 1915.
13. Some varieties of Indian gram, *Cicer arietinum,* L. (with Abdur Rahman Khan). *Memoirs of the Department of Agriculture in India (Botanical Series),* Vol. VII, No. 6, 1915.
14. Studies in Indian oil seeds. No. 1. Safflower and Mustard (with Abdur Rahman Khan). *Memoirs of the Department of Agriculture in India (Botanical Series),* Vol. VII, No. 7, 1915.
15. On the inheritance of some characters in wheat—II. *Memoirs of the Department of Agriculture in India (Botanical Series),* Vol. VII, No. 8, 1915.
16. The wheats of Baluchistan, Khorasan and the Kurrum Valley. *Memoirs of the Department of Agriculture in India (Botanical Series),* Vol. VIII, No. 1, 1916.
17. The storage of seed. *Agricultural Journal of India,* Vol. X, Part 3, 1915.
18. A new seed-drill. *Agricultural Journal of India,* Vol. X, Part 3, 1915.
19. Mixed crops. *Agricultural Journal of India,* Vol. XI, Part 3, 1916.
20. Zamin men hawa ki ámad va raft. *Risála 3, Quetta,* 1916.
21. Gehun ki ábpáshi men kifait shuari. *Risála 4, Quetta,* 1916.
22. Shaftal aur uska khamir shuda khushk chárá. *Risála 5, Quetta,* 1916.

REPORT OF THE IMPERIAL MYCOLOGIST.

(E. J. Butler, M.B., F.L.S.)

I. Charge and Establishment.

Mr. F. J. F. Shaw, B.Sc., A.R.C.S., officiated as Imperial Mycologist until November 16th, 1915, when I resumed charge of the section on return from combined leave. The post of Second Imperial Mycologist was created during the year and filled by Mr. Shaw, Supernumerary Mycologist, on October 19th, 1915. Muhammad A. Hafiz Khan, 3rd Assistant, was transferred on deputation to the Forest Research Institute, Dehra Dun, with effect from September 22nd, 1915. The vacancy thus created was filled by promotion from the staff, Babu N. C. Sen coming in as second clerk. Five of the staff volunteered for service in Mesopotamia in connection with the campaign against flies, just before the close of the year, and two of these have since been accepted. All have worked well.

II. Training and Visitors.

Babu J. B. Sinha, Fieldman in Mycology, Sabour, completed his course of training at Pusa on September 29th, 1915. Babu K. P. Roy, a scholar from the Bengal Department of Agriculture, joined on August 10th, 1915, and finished his course on May 31st, 1916. Mr. Deoki Nandan, B.A., M.R.A.C. and Mr. B. N. Vakil took special courses as private students from May 23rd and between March 15th and April 25th, respectively. Prof. K. C. Mehta, M.Sc., Professor of Botany, Agra College, worked in the section from March 3rd to 26th and Mr. G. S. Kulkarni, Mycological Assistant, Bombay, Department of Agriculture, from March 23rd to May 24th. Mr. A. C. Tunstall, Mycologist to the Indian Tea Association, visited the section from January 15th to 25th, 1916.

III. Diseases of Plants.

The investigation of the diseases of plants, the collection and identification of Indian parasitic fungi, and advice and assistance to officers of the Department and the general public, formed as usual the chief work of the section.

(1) Paddy diseases. The most important disease at present under investigation in the section is that known as "ufra" of rice, which continues to extend and attract increasing notice in Eastern Bengal. It is now throughout most of the districts of Noakhali, Tippera and Dacca and is extending into Mymensingh and probably Sylhet. With a view to testing measures for checking its ravages by experiments within the affected area, I selected a site near Comilla in 1912, and arranged for its acquisition as a temporary measure and also for complete control of its water supply by bunding, to prevent risk of infection from neighbouring fields. Subsequently it was decided by the local Department not to acquire the land, arrangements being made with the cultivators in the selected area to carry out our instructions. This did not prove satisfactory; the instructions were not followed, the bunds were defective and were cut through when water became scanty and the crop was harvested before it could be inspected. Owing to the evident difficulty of securing effective control of the selected site, it was abandoned last year and arrangements have been made to carry on the work in the neighbourhood of Dacca. Meanwhile small plots were instituted at Pusa in 1912, in order to duplicate the work under more rigorous control. It has been necessary to confine the Pusa work within narrow limits to avoid risk of the disease escaping from the plots to the surrounding cultivation; and only one or two experiments have been possible each season, outside those which could be carried on in the laboratory. The information obtained has, however, been considerable. It has been proved that a diseased plot will inevitably give a diseased crop the following year, if the stubble is allowed to rot on the ground as is the usual practice in the infected

area, but that if all the stubble is removed, a healthy crop can be grown. Furthermore it has been shown that the parasite can extend along the water courses, both with and against the stream, and infect neighbouring plots, but the distance travelled has hitherto been small. When atmospheric humidity within the crop is low, extension is hindered, but provided the humidity conditions are right, new cases of disease may become evident even on large plants within a month and many plants may be destroyed within two months of liberating the parasite in the water supply. Though under normal conditions the parasite passes into a dormant condition in the rotting stubble in the interval between successive crops (say from December to April), it can be kept in an actively parasitic state through this period by supplying it with constantly renewed young growing paddy for food, and this fact may increase our difficulties in dealing with it where the crop known as *boro* paddy is grown, fortunately a relatively small area. On present information it seems probable that the *boro* crop harbours the parasite, but that the low atmospheric humidity during the winter and spring months, when this crop is growing, checks extension and perhaps also interferes with the multiplication of the parasite. It is this same factor that doubtless explains the relatively little damage caused to the early (*aus*) crop and to the main crop in its early stages; experiments at Pusa have shown that so long as the above-ground parts of the plant are maintained dry, it is difficult to get successful infections, even though the roots and base of the plant are in mud and water, whereas during the monsoon or when inoculated plants are covered by bell jars, infection readily occurs. When insufficiently provided with moisture the parasite tends to pass into a dormant condition and ceases feeding.

Laboratory work was directed to attempts to establish conclusively that the cause of the disease is *Tylenchus angustus*, the eelworm described in Bulletin No. 34 of 1913. Attempts to obtain it in pure culture failed but conclusive proof was ultimately got by a series of experiments which

established that minute portions of infected plants were only infectious when they contained on them individuals of this species. During these experiments it was found that definite symptoms may be induced in healthy seedlings within a week when a moderate number of worms is used for inoculation. A minute strip of plant carrying, say, 20 worms can be relied on to produce the disease in covered seedlings, while a similar strip from the same plant and part but without worms, is harmless. About a hundred successful inoculations have now been carried out under conditions which leave no room for doubt that the actual parasite is this worm—perhaps the first case in which an ectoparasitic eelworm has been found causing serious injury to plants. Other points determined are that the worm is not strictly aquatic, as it perishes in some weeks if wholly immersed in water. Kept dry it lives longer, as it has the faculty of coiling itself up into a twisted mass, which resists moderate desiccation for at least some months. It appears to be unable to grow much or moult unless supplied with its usual living food and hitherto has not been found to grow or feed on anything else than living paddy plants. On paddy it is limited to parts where the outer walls of the epidermal cells are unthickened, and in young plants penetrates the bud to reach the young leaves near the growing point as soon as possible. This position is reached not by burrowing through the tissues but entirely by passing between the folds of the bud. Several experiments were carried out to test the ability of the worm to remain alive in soil, and the results indicate that it cannot survive during the interval between successive crops in this manner.

All the work hitherto carried out confirms the conclusion previously arrived at that the parasite is normally perpetuated by means of the stubble, which it is the practice in the infected area to leave on the fields after harvest. The problem of dealing with the disease therefore resolves itself into ascertaining the best way of removing or destroying this stubble. This can be done thoroughly by

raking it into heaps and burning it. It can perhaps be equally effectively carried out by early ploughing so as to bury the debris of the previous crop. Both these methods, however, are likely to interfere, if carried out on a large scale, with the local fodder supply and it seems necessary to ascertain whether diseased straw can safely be fed to cattle. There will be no need to defer active operations while such relatively minor points are being investigated, and it is hoped that the destruction of the stubble will be attempted on a large scale in the near future.

(2) "Tokra" of tobacco and mustard. The work of past two seasons has established that the parasitic species of *Orobanche* in Bihar are *O. indica* Ham. and *O. cernua* Loeffl. The species *O. cernua* is the common parasite of solanaceous crops in Bihar but does not appear to attack *Cruciferæ* save in very exceptional circumstances. In a crop of mustard, grown in a field known to be badly infected with both species of Orobanche, only four cases of *O. cernua* were found among many thousands of *O. indica*. The parasitism of *O. cernua* therefore is more restricted than is that of *O. indica* which, while being a serious parasite of *Cruciferæ*, does occur to a not inconsiderable extent on *Solanaceæ*. The life histories of the two species seem to be identical, the "tokras" appearing a few weeks after the host crop is well established and rising to flower and fruit along with it. Both species rely on the production of countless millions of minute seeds for their dissemination and perennation. These seeds are present all over the cultivated lands of Bihar, their number and minute size being extremely favourable to their dispersal in the strong winds of February and March when the fruits of *Orobanche* are ripe.

Experiments were carried out during the year with a view to discovering whether the addition of quantities of sodium nitrate to crops of mustard and tobacco had any influence on the number of "tokras" which occurred in the crops. Plots of equal size were selected in land which was known to be infected with both species of *Orobanche* and

the numbers of " tokras " occurring in plots to which sodium nitrate had been added were compared with the numbers of " tokras " in plots which had not received any nitrate. A difficulty which renders the results of the first season's work on these lines somewhat inconclusive is that the number of " tokras " appearing in a plot will depend, apart from any influence of artificial manures, on the amount of " tokra " seed which the plot contained. This factor appeared in many cases to mask any effect which might have been due to the addition of sodium nitrate. The work will be continued for another year in order to eliminate this source of error but the results obtained to date do not lend any support to the view that sodium nitrate will be found a specific remedy for " tokras."

(3) Black thread of rubber. Work on the " black thread " disease of Hevea in Burma was continued. A popular account was published as a bulletin of the Burma Department of Agriculture and a more technical memoir is in the press. The disease first breaks out soon after the rains begin and completely disappears after the close of the monsoon. It is not fatal to the tree but does much damage by attacking the tapped area of the bark. Infected areas do not yield latex and severely diseased trees have to be excluded from the tapping round. In 1914 the loss of rubber on one estate was 2—3,000 lb. and in 1915, 8—9,000 lb., there being 12,000 trees affected in 1914 and 42,000 in 1915, out of 77,000 in tapping. The cut surface of the tapped bark becomes marked by vertical cracks, from which latex occasionally exudes; sometimes a thick cushion of coagulated latex forms below the renewing bark, causing the latter to bulge out and ultimately fall off so as to leave an open wound. The renewal of the bark is irregular, masses of callus appear on the cut surface and further tapping is hindered.

The cause of this damage is a species of *Phytophthora*, differing from the well-known canker fungus, *Phytophthora Faberi*, to which it had been attributed in the Dutch Indies. It seems to occur in Ceylon also but has been there

supposed to result from climatic conditions. In South India the same fungus is believed to be responsible for considerable damage and it is at present under study by the Madras Department.

The fungus is found both in the diseased bark and also on the fruits. It has been grown in pure culture and an extensive series of inoculations carried out both on rubber and on numerous other plants known to be attacked by species of *Phytophthora*. On rubber it is a wound parasite, being unable to infect the undamaged bark; through wounds it infects readily and produces the characteristic symptoms of the disease. Of the other plants tried, the ordinary hosts of *Phytophthora infestans*, *Ph. parasitica* and *Ph. Colocasiæ*, the three species most commonly found in Northern India, are immune, as also is cacao, one of the chief hosts of *Ph. Faberi*, and many other plants known to be liable to *Phytophthora* attack. Only on seedlings of the garden plants, *Gilia* and *Salpiglossus*, were successful infections secured.

The disease is favoured by excessive humidity and shade and is, therefore, worst in thickly planted rubber estates. The free admission of sunlight and air checks its progress, and good results may be obtained from judicious pruning and thinning. The chief source of infection seems to be the fruits, and as these have practically no value, and develop in the rains a copious growth of the parasite, from which spores are shed on the bark, it is recommended that all fruits be carefully picked and destroyed before the monsoon breaks, in infected plantations.

In continuation of the studies on allied species of this genus which have been carried on at Pusa in recent years, an account of a form of *Phytophthora parasitica* found on *Vinca rosea* has been recently submitted for publication. Germination of the durable type of spore (the oospore) has been obtained and was found to correspond in essentials with that described for *Ph. erythroseptica* in Ireland.

(4) Opium poppy blight. The investigation of this disease has led to the conclusion that while *Peronospora*

arborescens is a normal parasite present in almost every poppy field and probably, like most of its tribe, only epidemic under favourable climatic conditions for its spread, *Rhizoctonia* develops chiefly in fields in which the drainage is defective. The Economic Botanist, United Provinces, has discovered certain varieties which appear to be almost immune to *Peronospora* and in the growth of these and improved cultivation and drainage lies the best hope of preventing loss of the crop.

(5) *Rhizoctonia* on jute and sugarcane. Samples of jute seed from Dacca were found to contain the sclerotia of *Rhizoctonia Solani* Kühn adhering to the seed. The parasitism of this fungus upon jute has been the subject of a previous publication but up to the present *R. Solani* has been a source of damage in the region of the " collar " and has not been known to infect seed. It is not clear how this comes about and the matter will receive further investigation.

Specimens of sugarcane received from the Central Provinces were found to be infected with a sclerotial fungus. The fungus was obtained in pure culture and strongly resembled *Rhizoctonia destruens* Tass.; moreover inoculations upon *Delphinium* (the original host of *R. destruens*) and upon betle vine were successful. Further infections upon sugarcane resulted in the death of the outer leaves and of the young shoots at the base of the plant; the infections are still progressing at the moment of writing. In the field the fungus causes a bright red spot on the leaf sheath and this is the first noticeable result in artificial infections. In badly diseased specimens the leaf bases are dark red and have a fibrous appearance as if the parenchyma had been rotted away leaving the vascular bundles. On stripping the leaf bases the stem has a pale pink colour under the epidermis and in section the interior shows a generally diffused salmon pink colour partly obscured by a thick white felt of hyphæ. The mycelium shows a tendency to form strands of hyphæ in a manner suggestive of *R. destruens*. Further research is in progress.

(6) Anthracnose of peppers. The disease of betle pepper referred to in previous reports as being probably due to an anthracnose fungus, has proved more difficult to elucidate than was anticipated. All attempts to produce it artificially by inoculating with cultures of the suspected fungi have failed. In the absence of definite knowledge of the cause no useful recommendations for treatment can be offered.

The chilli anthracnose (due to *Colletotrichum nigrum*) is a serious disease of this crop in several parts of India. It was prevalent in Bihar last year and some spraying experiments were tried. Later on it appeared that a more hopeful line of treatment lay in the use of disease-free seed and investigations are in progress to test this method. It has been found that, as in the allied bean anthracnose, the parasite penetrates the pod and reaches the seed. If such seed be sown the following season a certain number germinate and give seedlings on which the fungus may be found. Such seedlings must serve as a source of infection to their neighbours and it seems probable that this is one of the main ways by which the disease is perpetuated. If seed only from healthy pods be used this source of infection can be eliminated, and further experiments are in progress to test the effect of this on the subsequent crop.

(7) Plantain diseases. An account of a plantain disease prevalent at Pusa was published early in the year. It is a wilt, caused by a species of *Fusarium* allied to, but distinct from, that which causes the dreaded Panama disease of the New World. The parasite was grown in pure culture and successful inoculations with it secured. In mild attacks the growth of the plant is not checked but in more severe cases the rot reaches the stem and may kill the whole crown. Much loss is also caused when the stalk of the fruit bunch becomes attacked as this may lead to total destruction of the bunch. No method of treatment has been found.

A second plantain disease, familiar in India, is the fruit rot caused by *Gloeosporium musarum*. Attempts to

check this by spraying have been in progress for a considerable time. It has been found that early spraying with Burgundy mixture, beginning in June and repeated every fortnight until the fruit is nearly ripe, when ammoniacal copper carbonate should be used, is successful in preserving the fruit from the disease. An account of the method has been published.

(8) Sal tree disease. The disease of sál trees, mentioned for the first time in the last annual report of the section, has appeared again this year in the forest of Buxa Duars and is also reported in the Gorakhpur division. The symptoms of the disease and the fungus which occurs on diseased trees are exactly the same as in the previous description. Specimens of the fungus sent to Kew have been identified as *Polyporus Shoreæ* Wakefield—a species new to science—and the description published in the Kew Bulletin. The fungus is said to be readily distinguished from other species by the hard but brittle texture of the pileus, especially of the pores, when dry and the wrinkled deeply cracked dark crust. In living specimens the soft swollen whitish margin of the pileus is a distinctive feature. The basidia are normal and each bears fine hyaline spores from 2·5—3·5μ in diameter.

In culture the fungus grows well on a variety of media. On glucose agar the mycelium is largely submerged and produces a dense brown pigment; the hyphæ very often segment into spores. On sterile corn meal the fungus nearly always produces structures which suggest fructifications; so far however they have not produced any basidia or spores. The excretion of a yellowish liquid is a feature common to these structures in culture and to the pileus in the field.

Inoculations were carried out in the jungle at Rajahbhatkhawa in September of last year but defects in the method of this preliminary experiment, combined with the lateness of the season at the time of making the infection, proved unfavourable, and no conclusive results have so far been obtained. The inoculations were repeated this June,

with modifications suggested by the previous experiment, and a further series of infections is about to be carried out at Dehra Dun in co-operation with the Forest Botanist; it is hoped that these will yield decisive results.

(9) Other diseases of interest. The " black-dot " disease of potatoes caused by *Vermicularia varians*, was reported from Ranchi during the year. It was previously known only in France, Australia and South Africa. The extent of the injury it can cause is not yet determined. Peach leaf curl was found in the same locality and is reported to be very prevalent around Peshawar. It is hoped to arrange for trials in its treatment during the coming year. A disease of shaftal (*Trifolium repens*), caused by *Polythrincium Trifolii* (new to India) was found near Peshawar. Diseases of barley were much in evidence in the Pusa crop last season, the chief parasites recorded being *Puccinia simplex* and *Ustilago nuda* (not previously seen in India), *Puccinia glumarum*, *Ustilago Hordei* and *Helminthosporium gramineum*. A case of serious injury to a mango orchard at Malda from the fumes of a brick-kiln was examined. It differed from previous cases of the kind in the injury being chiefly to the fruit, not the branches. It is evident that the mango is peculiarly susceptible to such fumes. The study of the smuts of jowar, which are amongst the most destructive diseases in India, has been taken up by Mr. Kulkarni, Mycological Assistant to the Bombay Department of Agriculture, who completed his investigation at Pusa. No less than four distinct species attack this crop but the two more usual forms can readily be prevented by seed treatment. It is hoped to secure the universal adoption of this treatment ultimately, with a saving to the cultivators of several crores of rupees annually.

IV. Miscellaneous.

During my absence on leave the manuscript of a book on fungi as a cause of plant disease in India was almost completed. It has since been finished and revised and the

preparation of illustrations is now in hand. While engaged at Kew on this work an opportunity was taken of checking the nomenclature and determining the identity of many of the fungi that are responsible for crop diseases in India, by comparison with type material from the Herbarium of the Royal Botanic Gardens. I have to acknowledge the generous facilities given me by the Authorities at Kew and invaluable assistance from the Herbarium staff, especially Miss Wakefield and Messrs. Massee and Cotton.

As a result of the International Phytopathological Conference held at Rome early in 1914, the possibilities of legislation for the control of the spread of plant diseases have been recently much discussed. With the permission of the Secretary of State, I prepared a note for the Royal Horticultural Society on the dissemination of parasitic fungi as a basis for international legislation. This has since been written up with special reference to Indian problems and submitted for publication as a memoir of the Agricultural Department. At the Rome Conference a draft International Convention was signed by the delegates of some 30 States, and India will probably have to decide whether to adhere to this Convention or not, in the near future. Much consideration has been given to this question during the past year so that we may be in a position to advise when called on to do so.

V. Systematic Work.

The fifth part of "Fungi Indiæ Orientalis," based on material sent to Germany before the war, was published during the year. It includes a first instalment of determinations of the Pusa Herbarium collections of *Deuteromycetes*, comprising the *Sphaerioideæ* (173 species), *Nectrioideæ* (7 species), *Excipulaceæ* (4 species), *Leptostromataceæ* (3 species) and *Melanconiaceæ* (8 species). Seven new genera and 97 new species are described, the large proportion (nearly 50 per cent.) of new forms being due, no doubt, to the relatively little attention previously devoted to this group in the East. Many of them are crop parasites but

they are not, on the whole, responsible for as much damage as the mildews, rusts and smuts. The number of mounted sheets added to the herbarium during the year was 258.

VI. Programme of work for 1916-17.

(1) *Research work.* New fungus diseases of crops will be investigated as occasion arises but the following diseases will receive special attention and will constitute main lines of investigation.

(1) Ufra of paddy
(2) "Tokra" of tobacco and mustard
(3) Sclerotial disease and smut of sugarcane
(4) Wilt diseases of cotton, sesamum, gram and chilli
(5) Root rot of sál tree.

As minor investigations it is hoped to continue work on the anthracnoses of some field crops (especially chilli) and fruits.

(2) *Systematic work.* This will probably be in abeyance for the present, owing to difficulties in obtaining assistance from abroad on account of the war.

(3) *Training.* This will be continued on the same lines as in previous years.

(4) *Routine work.* Advice and assistance will be given as usual to Provincial Departments of Agriculture, the Forest Department, Planters' Associations and the general public.

VII. Publications.

(1) Shaw, F. J. F. & S. L. Ajrekar. The genus Rhizoctonia in India. *Mem. Dept. of Agri., India, Bot. Ser.* VII, No. 4, August, 1915.

(2) Shaw, F. J. F. . Report on Mycology, 1914-15, for the Board of Scientific Advice.

(3) Dastur, J. F. . A Rot of Bananas. *Agr. Jour. of India,* Vol. X, Part 3, July, 1915.

(4) Dastur, J. F. . Spraying for Ripe-rot of the Plantain Fruit. *Agr. Jour. of India,* Vol. XI, Part 2, April, 1916.

(5) Dastur, J. F. . Black Thread disease of Hevea in Burma. *Bull. 14, Department of Agriculture, Burma,* 1916.

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REPORT OF THE IMPERIAL ENTOMOLOGIST.

(T. Bainbrigge Fletcher, F.L.S., F.E.S., F.Z.S.)

I. Charge and Establishment.

The Imperial Entomologist held charge of the Section throughout the year ended 30th June 1916. The post of Supernumerary Entomologist remained vacant throughout the year owing to the impossibility of obtaining any suitable candidate during the war. Mr. Misra, First Assistant, was on privilege leave from 24th May until the close of the year under review. Mr. C. C. Ghosh was granted a personal scale of pay of Rs. 200—5—250. Mr. D. Nowroji was on privilege leave from 25th October to 20th November 1915. G. D. Ojha and D. P. Singh, Fieldmen, were employed in the Central Provinces, from the commencement of the year to 9th October and from August to November respectively, in connection with the outbreak of "Maho" (*Nephotettix bipunctatus*).

At the close of the year, volunteers were called for for Fly Control work with the Expeditionary Forces in Mesopotamia. T. V. Subramania, Typist, and P. Narayanan, Artist, of this Section, together with D. P. Singh, Fieldman, on the staff of the Imperial Pathological Entomologist but actually employed in Entomological Section, volunteered and were selected and sent. A quantity of apparatus and four sprayers were also sent to Mesopotamia in compliance with indents received from the Army Department.

II. Tours.

The Imperial Entomologist was on tour in Madras from 18th August to 4th September 1915, in Coorg from 10th October to 23rd November, in the Central Provinces from 14th to 22nd March 1916, and in the North-West Frontier Province from 16th April to 20th June, a total absence from headquarters of 139 days.

Mr. C. S. Misra, First Assistant, visited the Central Provinces and Berar from 3rd to 26th October 1915 in connection with the outbreak of "Maho" (*Nephotettix bipunctatus*) and to study sugarcane pests.

Mr. C. C. Ghosh visited Ranchi from 9th to 15th September 1915 to investigate a stem-gall disease of rice plants caused by *Pachydiplosis oryzæ*, Wood-Mason.

Mr. M. N. De, Sericultural Assistant, toured in Bengal, to see the Silk Centres, from 11th to 21st July 1915.

The Fieldmen were sent on tour as occasion required throughout the year, chiefly in connection with outbreaks of pests. H. H. Prasad, Sericultural Fieldman, with two spinners and three rearers, was sent to the Madras Peoples Park Fair in December 1915, to show a complete working exhibit of Sericulture from egg to cloth.

III. Training.

Two students from the Punjab were under training in Entomology from the commencement of the year under review to 31st March 1916. Two students were also received for the course commencing on 1st June 1916 and remain under training; of these one was sent by Patiala State, the other is a private student. Mr. Mehdi Hasan, of Hyderabad (Deccan), worked in the Laboratory, from 23rd August 1915 to 27th January 1916, mostly on ants. The short courses in Lac-culture attracted no students during the year; this is probably due, as noted in last year's report, to the publication of a popular Bulletin on Lac-work. In Sericulture three students completed short courses in Eri and Mulberry Silk and three remained under training at the close of the year.

IV. Insect Pests.

The following list shows, under the heading of a few main crops, the more important investigations carried out during the year on various insect pests of crops. Other work is shown under other headings (Life-histories, etc.),

but it is not possible, in a brief report of this nature, to mention, even by name, all the insects dealt with during the year :—

1. Cotton. Experiments, commenced last year, were continued to test the relative immunity to bollworm attack of different varieties of cotton from the United Provinces, the Punjab, Bombay, the Central Provinces, and Madras. With this object in view, two sowings of each variety were made, one planted thickly and the other thinly, and weekly counts of affected bolls have been made separately for each series. The parasites that emerged were counted, recorded, and liberated; their hibernation and alternative hosts were also studied. One unexpected discovery was that there are apparently at least five different species of *Rhogas* which attack cotton bollworms (*Earias fabia* and *E. insulana*); their discrimination may prove to be of practical importance in control of bollworm by means of its parasites. The life-history of *Earias fabia* was worked out and repeated; it will be repeated again for the different seasons of the year. The seasonal colour variation of bollworm moths was also studied and a long series of specimens retained showing range of variation. Studies were also made of the utility of trap crops in connection with control of bollworm. The advantage of sowing cotton as a mixed crop was also studied and these experiments will be continued and the results written up as requisite.

At the end of May 1915, the Director of Agriculture, Punjab, requested the despatch to Hansi of bollworm parasites in order to establish a breeding plot and so facilitate their distribution in the Punjab. Between 7th June and 22nd July 1915, 158 grubs and pupæ of *Rhogas* spp. were despatched from Pusa to Hansi, and after the latter date sendings were discontinued as the parasites were fully established in the experimental plots at Hansi.

2. Rice. A diseased condition of growing rice plants, by which the whole growing stem is converted into a long, white, hollow gall, has long been supposed to be due to

attack by a Cecidomyiad fly, but little was really known about it, although a loss of thirty per cent. or more of the crop sometimes occurs. An outbreak of this disease being reported from Ranchi in September 1915, opportunity was taken to study it and it was found that the gall-formation is caused by a small fly (*Pachydiplosis oryzæ*, Wood-Mason) whose life-history was worked out in some detail, but further observations and experiments are required before the recommendation of control measures on a field scale.

Jassid bugs, locally known as "Maho," under which name are included *Nephotettix bipunctatus*, *N. apicalis* and (in less numbers) other similar species, have become a serious pest of paddy in the Central Provinces during the past two years. To help in investigation and control of this outbreak one Fieldman was lent from Pusa for the period April-October 1915 and a second Fieldman in August-November. Mr. Misra, First Assistant, also visited the affected areas in October to investigate the pest, note the damage done, and assist in control work.

Considerable attention has also been paid to these species of *Nephotettix* at Pusa, as regards their exact life-history, hibernation and alternative food-plants, but so far very little light has been thrown on these points. Numerous attempts to breed *Nephotettix bipunctatus* from the egg in captivity have been uniformly unsuccessful. Grass lands and areas which were under rice last season were frequently bagged and a powerful light-trap was also placed in these areas but, from the beginning of December 1915 up to 26th June 1916, not a single specimen of *Nephotettix* could be found, the first example being found amongst grass on 27th June 1916. There is therefore at present an interval of some seven months in the year, during which we know nothing of the life-history of this insect. Work is being continued.

Specimens of Fulgorid bugs, also found on rice in the Central Provinces, have been identified by Mr. W. L. Distant as *Sogata pusana*, *S. pallescens* and *S. distincta*.

Mealy-bugs on rice at Balasore have been identified by Mr. E. Ernest Green as *Ripersia sacchari niger*.

3. Sugarcane. The work of rearing cane-borers was continued, fresh affected cane, maize, juar, millets, wild grasses, etc., being collected and the borers and their parasites reared out. Several broods of moths, bred from known parents themselves reared in both cane and juar, were also reared to ascertain the variability of certain characters. As material accumulates it seems to become increasingly evident that the cane-borers are two or more species of *Diatræa*, which may occasionally attack juar, maize, etc., and that the normal borer in these cereal crops is *Chilo simplex* which is rarely found in cane. Further collection and study are required of material from all parts of India as the question of identity is of importance as regards control.

From observations made at Tharsa Farm, in the Central Provinces, it seems that there is some possibility of reducing the incidence of borers (in this case principally *Schœnobius*) by varying the time of planting the cane. With this view a small experimental plot of half an acre under both thick and thin varieties of cane was planted by the end of October 1915.

Two Fieldmen were detailed to assist the farm in selection of cane setts for planting in February and March.

Observations on *Pyrilla aberrans* were written up and submitted for publication as a Memoir (now in the press).

The sugarcane Aleyrodid (*Aleurolobus barodensis*) was reported from Tharsa as doing considerable damage to canes in the experimental plots. Measures for control were suggested and a large amount of material was also collected and reared to find out whether any effective parasite was present; but no parasite of any importance was obtained.

Papua depressella has hitherto been noted as boring principally in the roots of cane, being mostly in evidence in the ratoon crop. This year it exhibited a new habit by attacking new shoots of newly-planted cane in the early

part of the hot weather (April-May), causing greater damage than either *Diatræa* or *Scirpophaga*. The external symptom of attack is " dead-heart " as is the case of boring by *Diatræa*, *Scirpophaga* and *Sesamia*.

A series of experiments was carried out on the protection of cane setts from attack of termites, the following substances being tried, *viz.*—Lead Arsenate, Resin Compound, Fish-oil Soap with Resin, Crude Oil Emulsion, and Naphthaline Emulsion. Of these Lead Arsenate proved to be the best. In this connection it may be observed that it is not only the setts themselves which require protection but also the new shoots—in fact, in most cases the shoots are most attacked, being eaten into at the point of exit from the sett. It is of course much more difficult to protect these shoots than the setts and, to achieve this, additional treatment is usually necessary. Further experiments will be undertaken on this line next season.

4. Indigo. During the year two Indigo Pests (Indigo Aphid and *Dichomeris ianthes*) were reported from two factories, Barh Chakia and Tateriah, both in North Bihar. A Fieldman was sent to spray the infested fields with Soap Solution. Two sprayings were given and the effect was reported to be good by the Managers of the factories concerned.

5. Coffee. The year 1915 was marked by a very bad outbreak of Coffee Borer (*Xylotrechus quadripes*) in Coorg. One group of estates in S. Coorg, of about 500 acres, removed approximately 100,000 bored bushes between 1st June and 31st October 1915. The Imperial Entomologist toured in Coorg in October and November to investigate this insect. The beetles began to emerge in the last week of October and were common by the first week of November. Eggs were obtained and hatched out and it was proved that sunshine is not essential to the hatching of the eggs, as stated by former observers. The eggs, which are white, soft, of rather indeterminate shape rather like minute rice-grains, are thrust singly or in little groups (of about 6-8)

inside cracks and under scales of bark of coffee bushes; they are rarely visible, and very rarely laid externally. Experiments were started to ascertain the length of life-cycle, as it has been uncertain whether there are one or two broods in the year. Results will be written up when further information on these experiments comes to hand.

Information was also collected on pests of *Erythrina lithosperma*, which is extensively grown for shade and green-manure on Coffee Estates.

6. Orchard and Garden Pests. A special study has been made during the last three years of Insect Pests of cultivated Fruits, Vegetables and Flowers, and a considerable amount of information has been collected on the insects concerned, their identity, life-history, foodplants, occurrence and control. This information will, it is hoped, be issued shortly as a Bulletin.

Special attention has also been paid to the collection of Fruitflies. A large collection of these was sent to Professor Mario Bezzi, of Turin, last year but was apparently lost in the S.S. "Persia" on return after identification; fortunately, the types of eight new species had been sent direct to the British Museum by Prof. Bezzi. *Myiopardalis pardalina*, the "Baluchistan Melon Fly," was reared at Pusa from fruits of *Cucumis trigonus;* it was not hitherto known to occur except in North-Western India.

An important find during the year was the European Olive Fly (*Dacus oleae*) in wild olives in the North-West Frontier Province. Its occurrence in India was hitherto unknown and it is likely to be of importance in view of the attempts now being made to introduce the cultivation of the European olive in North-West India and Kashmir.

7. Life-histories of Insects. In the Insectary were reared about 200 species of insects which had not been reared before. These included about fifty Coleoptera, of various families, of which there was no previous information regarding their breeding-places and habits. Many interesting facts have been noted in this connection; for example, one Elaterid beetle grub (*Agrypnus* sp.) has now

been living in the Insectary for twenty-one months, its food consisting of Scarabæid and other beetle grubs with similar habits of working under the surface of the soil, most of them damaging roots of plants.

As mentioned in last year's report, *Bruchus affinis* was observed to lay eggs extensively on pea-pods at Pusa in January and February, so that the peas may be infected in the field before being stored. The habits of this beetle have since been investigated more thoroughly. The grubs are brought into the store inside the seeds which are externally quite sound at harvest-time, about the end of January. The beetles begin to emerge from the seeds in August, but they do not become active until about December or January, the majority of the beetles remaining inside the seeds and thus having a chance of being taken back to the field at sowing-time. Seeds from pods on which eggs were laid suffered to the extent of about 50 per cent. of the crop, whilst the remainder of this same crop (after separation of those pods with visible eggs) suffered a damage of only 3-5 per cent., and this was probably due to a small percentage of eggs being passed over. Treatment with Carbon Bisulphide or Naphthaline successfully prevented damage to the peas in store. A simple treatment (immersion of the seeds in water, when those attacked float and the unattacked seeds sink) has been found efficient for separation of the affected from the unaffected seeds and therefore it is possible to avoid liberation of the beetles in the field at the sowing time.

Bruchus chinensis breeds throughout the year in Pulse seeds in store. This insect has been observed to breed in Gram, Mung (*Phaseolus mungo*), Urid (*P. radiatus*), Bakla (*P. aconitifolius*), Kulthi (*Dolichos biflorus*), Lentil, Khesari (*Lathyrus sativus*), Arhar (*Cajanus indicus*), Bora (*Vigna catjang*), and large and medium peas. A small variety of local indigenous pea has been found to be immune from its attack. Eggs are laid on this variety as on others, but the grubs cannot bore or feed in this pea, which is, however, more liable to attack by *Bruchus affinis* in the field.

The work of breeding *Agrotis ypsilon*, referred to in last year's report, was continued in order to find out how it passes through the Hot Weather and Rains (April-September). In the Insectary it continued to breed throughout this period. The moths, however, which emerged in July-August did not lay fertile eggs although they had full chances of mating; possibly this was due to inbreeding under unfavourable conditions; at any rate, fertile eggs were not obtained. But, as it was, the insect bred in captivity until about the time (August) when the moths normally appear in the *tal* lands which are subject to attack at Mokameh. During 1916 an Andres-Maire trap was worked in the Insectary compound at Pusa throughout the hot weather (April-June) to see whether any moths of *Agrotis ypsilon* could be attracted but not a single example was captured. What actually happens under normal conditions remains, therefore, still a mystery. The insect can continue to breed under favourable conditions but we have no evidence that it actually does so: our Insectary experience has yielded no indication of any inclination to pass through the hot weather in any resting stage; on the contrary, breeding was continuous until August. On the other hand no trace of the insect has been found under natural conditions between April and August. The migration theory fits the known facts but as yet remains an unproved hypothesis.

Colonies of *Odontotermes assmuthi*, established in artificial breeding cages (tiles) in the Insectary, died out after about four months, by which time adult workers and soldiers had been obtained. One colony, however, which had been planted out in a cage in the ground in the Insectary compound, could be traced for a whole year, after which it dwindled away; even after this period, however, the queen showed no particular sign of a dilated abdomen.

The habits of *Metriona circumdata*, *Aspidomorpha indica* and *Philemostoma trilineata* were observed throughout the year. The beetles hibernate and live for about six months.

The life-history of *Ancylolomia chrysographella* was also traced throughout the cold weather (November-February). This moth hibernates in the larval stage and breeds continuously in the hot weather.

Two tube-forming Tineid larvæ, *Melasina* sp. and *Myrmecozela leontina*, both with only one brood in the year, were also under observation.

The life-history of *Leucophlebia lineatâ* (Sphingidæ) was traced throughout the year. The larvæ were noted to hibernate as well as æstivate.

Oides bipunctata (Chrysomelidæ) has been observed to hibernate and æstivate in the egg stage.

Polytela gloriosæ (Noctuidæ) has been observed to hibernate and æstivate in the pupal stage.

The already known habit of larval æstivation in *Mudaria cornifrons* (Noctuidœ) was confirmed by further observations.

In connection with other experiments on *Bactrocera cucurbitæ* (Trypaneidæ) it was noted that this Fruit-fly is capable of living in confinement in the adult state for a period of over three months. Under natural conditions it seems probable that many Fruit-flies live over from season to season in the adult state. It was also noted that stems of Cucurbitaceous plants and galls thereon, caused by Cecidomyiadæ or otherwise, were as favourable breeding-places for these flies as the fruits themselves.

In addition to the foregoing, complete cycles were observed of *Danais plexippus* (on *Oxystelona esculentum*, a new food-plant), *Kolla mimica* on paddy, a Jassid bug on sugarcane leaves, another Jassid on leaves of *Cyperus rotunda* (*Mutha*), *Polia consanguis*, a Halticid beetle on *Anisomeles ovata*, and *Cyrtacanthacris ranacea*.

A few broods from known parents were reared of *Terias hecabe* and *Papilio polytes* to ascertain proportional variation.

Further observations were made on the habits of *Tenebroides mauritanicus*, *Odoiporus longicollis*, *Attagenus*

piceus, Lepisma sp., *Chilo simplex, Laspeyresia pseudonectis* and many other insects. Special attention was paid to leaf-mining Lepidoptera and numerous species, including many hitherto undescribed novelties, were bred out from crops and other plants.

Unsuccessful attempts were made to breed *Nephotettix bipunctatus, Zonabris pustulata, Lytta actæon,* and *Heliocopris bucephalus.*

Large numbers of Fruit-flies were reared out to discover to what extent they are checked by parasites but it was found that the proportion of parasites is extremely low. The only Fruit-fly which is parasitized to any appreciable extent is *Carpomyia vesuviana*, whose larvæ feed in fruits of *Zizyphus jujuba.* About 800 pupæ of this fly were sent to Italy, to endeavour to introduce the parasite there, but owing to postal delays they failed to reach their destination alive.

8. Insecticides. A series of experiments was carried out to test the effect of poisoned sprays on Fruit-flies, the species used being *Bactrocera cucurbitæ.* It was found that a spray of *gur* (sugar) and Lead Arsenate killed the flies in the course of about 36 hours. A similar mixture, of *gur* and Lead Chromate, had practically no effect and proved quite useless as a poison.

9. Protection of Timber against Termites. The trials under this heading were continued. Further tests of Powellized wood and of Microlineum were made. Preliminary tests of Sideroleum were made, further tests being held in abeyance pending receipt of more material promised by the Agents of this preparation. Tests of Timborite were put in hand.

10. Grain storage experiments. The storage of wheat, rice and pulses, commenced last year, has been undertaken this year on a larger scale based on the first year's results. In addition, in order to determine the pests of stored products more exactly, over sixty different substances have been placed under ordinary storage conditions for observation of their insect pests.

As a result of the first year's experiments, the lime treatment of rice has been found most satisfactory, the stored rice being rendered practically immune from all pests without impairing the edible qualities. It must, however, be noted that the preliminary experiment was done on a very small scale and further tests on a larger scale are now in hand to check this result. The same remark applies to several other samples of wheat and pulses treated in different ways, and all are being retested on a larger scale. One curious case may, however, be mentioned here as at present it seems rather inexplicable; a jar of wheat grains infested with *Calandra oryzæ* had about half an inch in depth of dry sand spread evenly in a layer over the top of the wheat; in due course the weevils emerged and made their way up through the sand which, however, they seemed unable to penetrate again, and all the adult weevils died and formed a layer on top of the sand, leaving the underlying wheat grains unaffected by any further weevils. At first sight it seemed that the experiment had been successful and that a simple layer of dry sand would form an efficient protection for wheat stored either for sowing or for food; but, on testing, this wheat failed to germinate. It was closed up in a glass jar : but so were other samples, equally, more, and less affected by weevils, and kept in exactly similar jars; yet these other samples germinated successfully.

V. Bees, Lac and Silk.

1. Bees. Experiments with *Apis indica* were continued. The Wax Moth (*Galleria mellonella*) gained entrance to the hives at an unexpected period (December) and destroyed five out of seven colonies; other colonies were procured but these were a little too late for the honey flow.

One colony of *Apis indica* was specially worked (1) to check swarming and (2) to attain the maximum yield of honey. Swarming was checked successfully and the yield of surplus honey was 15½ lb. *i.e.*, about double the ordinary quantity. The result was attained by improved methods

and an adequate supply of ready-made combs at the proper time. Work on these lines will be continued.

Several requests for Frame hives, Comb Foundation and other Bee-keeping requisites, from various inquirers, have been met as far as possible.

No further experiments have been made with European Bees owing to the great danger of introduction of Isle-of-Wight Disease into India. In this connection a word of warning may well be issued to any would-be importers of European bees.

A Bengali Bulletin on Bee-keeping has been written up and will be sent in for publication at an early date.

2. Lac. The emergence of Lac larvæ took place at Pusa on 30th September 1915 and 12th June 1916, and sixty large *Ber* trees were inoculated.

Three Lac Show-cases were sent to the Chandernagore Exhibition, in December 1915, together with copies of the Lac Bulletin (in English and Hindi) for distribution to interested inquirers.

A demonstration in Lac-culture was given to the students from the Sabour Agricultural College who visited the Institute.

No students attended the short courses in Lac-culture.

Numerous inquiries for Brood-lac, etc., were dealt with during the year.

3. Silk. Three students completed short courses in Eri and Mulberry Silk-work and three remained under training at the close of the year. Eri silkworm eggs were distributed to 89 applicants and Mulberry silkworm eggs to 70 applicants. Eri eggs and castor seed were sent to the Agricultural Department in Mauritius, where they arrived safely and have done well. Mulberry and Castor seeds, Mulberry cuttings and samples of different kinds of silk were distributed to numerous inquirers. Instructions for rearing, reeling, dyeing, bleaching, and spinning were given by correspondence. The Univoltine Mulberry silkworm eggs which were sent to Shillong and Muktesar for cold

storage gave satisfactory results on rearing in March, but those sent to Guindy for rearing in October were not successful. Some of the hybrid multivoltine races, which have been under selective rearing during the last four years, were reared on a large scale and gave satisfactory results, the outturn of reeled silk in all cases being superior to pure multivoltine races but inferior to univoltines. Silk Exhibits were sent to the Agricultural Show at Muzaffarpur and to the Exhibitions held at Chandernagore and Madras; a complete working exhibit, showing the whole process of sericulture from the egg to the finished cloth, was sent to the Madras Exhibition and proved a considerable attraction. A rearer was lent to Rewah State to demonstrate Mulberry silkworm rearing and reeling. The services of Harihar Prasad, Silk Fieldman, were placed at the disposal of the Imperial Agricultural Bacteriologist in connection with his work on investigation of Pebrine in Mulberry Silkworms.

A Bengali translation of Bulletin No. 48 (First Report on Mulberry Silk Experiments) was printed during the year, and a second edition of Bulletin No. 39 (Instructions for rearing Mulberry Silkworms) is now in the press. A Second Report on the Mulberry Silk Experiments has been written up. Articles on Mulberry Silk were also contributed to the Bengal Journal " Grihastha."

Visitors to the Silk House included Miss M. L. Cleghorn (on special silk duty under the Government of Bengal), Mr. De Minville, and Mr. H. Maxwell-Lefroy, Imperial Silk Specialist.

Silk pieces, to the value of Rs. 504-13-0, were sold during the year and the proceeds credited to Government.

Some experiments were carried out with *Tricolyga sorbillans*, Wied. (*bombycis*), the Tachinid parasite of silkworms, in connection with its method of oviposition and breeding-habits. The following caterpillars were exposed to attacks of the flies, *viz.*:—Mulberry silkworms (*Bombyx mori*), Eri silkworms (*Attacus ricini*), *Achœa janata*, *Spodoptera mauritia*, *Polytela gloriosæ*, *Cosmophila sabulifera*, *Papilio demoleus*, *Utetheisa pulchella*, and

Diacrisia obliqua, of which the last two are hairy and the others smooth-skinned. The flies were found to oviposit on all the varieties of caterpillars, whether hairy or smooth, but could not breed in other caterpillars so successfully as they could in the silkworms. Flies were actually bred out only from the parasitized larvæ of *Cosmophila sabulifera* but from the experiments it appeared that the flies could, if necessary, breed in the other caterpillars.

VI. Illustrations.

Coloured plates illustrating the life-histories of the following insects were prepared during the year, *viz.*:— *Pachydiplosis oryzæ*,* *Papua depressella*, *Phyllocnistis citrella*, *Chloridea assulta*,* *Kolla mimica*, *Oedematopoda clerodendronella*, *Epicephala chalybaema*, *Terias hecabe*,* of which those marked * are now in press and will be available shortly.

A coloured plate of orange fruits was also prepared for the Agricultural Officer, North-West Frontier Province. Besides the completed coloured plates, a large number of figures, in colour and line, was drawn of various insects and these will be utilized for publications in due course.

There is always a heavy pressure of work to be done by the Artist Staff and our life-history work is constantly handicapped by insufficient artistic assistance.

A list of all the coloured plates of Indian insects, prepared to date, was issued during the year, mainly for the information of Provincial Entomological Staffs. This list shows for each insect whether the coloured plate has been printed and, if published, in what publications it has appeared.

The issue of coloured plates and lantern slides has been continued.

VII. Miscellaneous.

Correspondence. A total of 95 parcels of specimens, mostly of crop-pests, was received during the year for identification and advice, whilst 1,090 letters were received

and 1,422 issued, but all these numbers are exclusive of a large amount of routine correspondence. As the activities of the Section become better known, the correspondence becomes more and more onerous and takes up more time which should be devoted to more productive work.

VIII. Insect Survey.

Steady progress has been made in additions to, and arrangement of, the collection. The whole of the collection of Lepidoptera has been overhauled, rearranged and placed in one series, so that all the information on any species or group is now available in one place. The same is being done with the Coleoptera, which are nearly finished, and other groups will be taken up as time and staff permit. Work of this sort takes time and care, but is necessary as, in the not infrequent case of non-identification or misidentification of an insect at the time of its collection or occurrence as a pest, the specimen itself forms the only evidence of its identity and if it is hidden away, out of the series, as a "duplicate" or "non-identifiable," valuable information may easily be overlooked.

The collections continue in good order but the difficulty of maintaining them, in boxes in open racks in a climate such as that of Pusa, is very great.

The following collections were sent out to Specialists in the groups named and our thanks are due to them for the help afforded :—

(*i*) Micro-Lepidoptera to Mr. E. Meyrick, F.R.S., to whom special thanks are due for his examination of the whole of our unnamed material, of which about forty per cent. proved to be new to Science. The novelties are under description in "Exotic Microlepidoptera." A Memoir on life-histories of Indian Microlepidoptera, comprising all the information published hitherto together with a mass of new material now rendered available by the identifications received, is now in preparation.

(*ii*) Rhynchota to Mr. W. L. Distant. Much of the new material has been utilized in Volume VI of *Rhynchota*, lately published in the "Fauna of British India" series. Some of our material has been received back.

(*iii*) Rutelidæ to Mr. G. J. Arrow, who will use this material for his "Fauna" volume on this group. Specimens returned, named.

(*iv*) Carabidæ to Mr. H. E. Andrewes, who is working on the Indian species of this group. Partly returned, named.

(*v*) Trypaneidæ to Professor Mario Bezzi of Turin. The specimens were named and we were advised of their return, but they have not been received and were presumably lost in the S.S. "Persia." Types of eight new species had fortunately been sent direct to the British Museum by Professor Bezzi.

(*vi*) Parasites of Trypaneidæ to Professor Silvestri, Portici, Italy. Not yet returned.

(*vii*) A Dryinid parasite on nymphs of *Pyrilla* spp. to Mr. J. C. Crawford. Named as *Chlorodryinus pallidus*, Crawf.

(*viii*) Cecidomyiadæ to Professor E. P. Felt. They have been named and the collection retained for the present.

(*ix*) Sphegidæ to Mr. Rowland Turner. Not yet received back.

(*x*) Apidæ to Mr. G. Meade-Waldo, whose recent untimely death has deprived us of a most valued correspondent who was always willing to give us every help in identification of our specimens. This collection remains at the British Museum and will probably be transferred to Professor Cockerell for examination.

(*xi*) Curculionidæ to Mr. G. A. K. Marshall. Partly named and returned.

(*xii*) Cerambycidæ to Mr. C. J. Gahan. Not yet returned.

(*xiii*) Histeridæ to Mr. Lewis. Not yet returned.

(*xiv*) Coccidæ to Mr. E. Ernest Green. Partly named and returned.

(*xv*) Diptera (various groups) to Mr. E. Brunetti, who has taken much time and trouble in affording us help.

(*xvi*) Towards the close of the year the manuscript of a paper descriptive of a collection of Indian Termites, sent in 1912-13, was received from Professor Nils Holmgren, of Stockholm. This paper is written in German and will require translation before publication. It contains descriptions of numerous new species and the issue of these will enable a mass of notes on these species to be written up for publication.

(*xvii*) Examples of *Stibaropus minor*, Wlk., found in an Ant's nest were sent to Mr. Donisthorpe, who, however, considered that they were not myrmecophilous insects.

(*xviii*) A collection of *Rhogas* spp. was sent to Mr. C. T. Brues, United States of America, for identification and description of the new species.

(*xix*) A mite found attacking the cocoons of a Burmese Ant, *Ectatomma coxale*, was sent for examination by Mr. S. Hirst, who writes that it is a new species of the genus *Urodinychus*, Berlese. Some species of this genus are known from Europe, a few from Africa and one from Java, and of these some have been found in ants' nests but very little is known about their habits.

Various collections of Indian insects have been received and named and returned as far as possible; these included (*i*) a collection of Rhynchota from Mrs. Kilby, (*ii*) Microlepidoptera from Coimbatore Agricultural College, (*iii*)

insects from birds' stomachs sent by the Nagpur Museum, (*iv*) various insects from Nagpur Agricultural College, (*v*) various insects from Entomological Assistant, Burma, (*vi*) collections of Hymenoptera, Lepidoptera, and Rhynchota from Mr. C. Inglis, besides numerous other small sendings.

IX. Programme of work for 1916-17.

Major.

This will follow generally on the lines of work of the current year and will include general investigations of crop pests and especially of the pests of rice, sugarcane and cotton, of fruit-trees and of stored grain.

Minor.

A commencement has been made of collection of information for a general book on the crop pests of India and progress in this will be continued, as also in the publication of information regarding life-histories of pests and coloured plates, of which a large number are now ready for printing. Work and experiments in silk, lac and bee-keeping will be continued, and new insecticides and insecticidal methods tested as occasion arises. Advice and assistance will be given as far as possible to Provincial Departments and to all inquirers on entomological subjects.

X. Publications.

The following publications have been actually issued during the year :—

De, M. N. . . . Instructions for rearing Mulberry Silkworms. [*Bulletin 39 (Revised Edition), Agricultural Research Institute, Pusa.*]

Fletcher, T. Bainbrigge. Bees and the Fertilization of Coffee. (*Bulletin 69, Madras Department of Agriculture.*)

Fletcher, T. Bainbrigge. One Hundred Notes on Indian Insects. (*Bulletin 59, Agricultural Research Institute, Pusa.*)

Fletcher, T. Bainbrigge.	Report on Agricultural Entomology, 1914-15. (*Board of Scientific Advice Annual Report.*)
Misra, C. S. . .	Report on Investigations regarding the Maho (*Nephotettix bipunctatus* and *N. apicalis*) in the Central Provinces, October 1915. (*Central Provinces Department of Agriculture.*)

REPORT OF THE IMPERIAL PATHOLOGICAL ENTOMOLOGIST.

(T. Bainbrigge Fletcher, F.L.S., F.E.S., F.Z.S.)

I. Charge and establishment.

Mr. F. M. Howlett, B.A., F.E.S., Imperial Pathological Entomologist, was in charge of the section from 1st July to 28th July 1915, after which he proceeded on six months' combined leave, afterwards commuted into leave on medical certificate and extended by a further period of six months. Mr. B. Coventry, C.I.E., Agricultural Adviser and Director, was in charge from 29th July to 8th August, and the Imperial Entomologist was in charge of the work, in addition to his own duties, from 9th August to the close of the year (30th June 1916).

Mr. P. G. Patel was absent on privilege leave from 3rd to 22nd January 1916, Mr. H. N. Sharma from 8th to 20th December 1915, and Mr. S. K. Sen, from 25th October to 4th December 1915.

In response to a call for volunteers for Fly Control work with the Expeditionary Forces in Mesopotamia, Messrs. Patel and Sharma volunteered their services at the close of the year and have since proceeded.

Tours. Mr. P. G. Patel visited Kathgodam and Bareilly from 12th September to 23rd December to collect and study biting flies in connection with the Imperial Bacteriologist's experiments on Surra transmission.

Mr. S. K. Sen toured in Madras and Bengal from 21st July to 12th September 1915.

Correspondence. The number of letters received and issued during the year amounted to 211 and 228 respectively, whilst 151 parcels of specimens were also received and dealt with. Most of these parcels were of maggots causing myiasis in domestic animals, but several lots of mosquitos, ticks, etc., received for identification, were dealt with.

II. Work done. Disease-carrying insects.

Cattle Flies.

Observations were continued on the life-histories of various Tabanidæ occurring at Pusa. As regards the feeding-habits of Tabanid larvæ it was noted that cannibalism is not universal; at least, so far as observed, larvæ of *Tabanus nemocallosus* do not attack and destroy one another. Forty nearly full-grown larvæ of this species were collected and confined in a very small glass vessel, with some moist earth, but actual counts made twice weekly discovered no larvæ missing or damaged. Of these larvæ, collected on 27th January, only a very few emerged as flies in March, the majority in April and May, and a few in June. The pupal period is eight or nine days. One larva kept under submerged conditions lived for over three months in water without any food; these larvæ must therefore have a respiratory system fitted for both aquatic and terrestrial life and can exist over a considerable period if conditions are unfavourable. Egg-masses of *T. nemocallosus* were found fairly commonly from the third week in April; this species appears to be rather gregarious in its egg-laying habits, depositing its egg-masses by preference on *Phragmites*. The newly hatched larvæ are also gregarious in habit, often noted to be crowded up in a mass in one place in the breeding vessel. Grown larvæ are also more or less gregarious, as on one occasion 63 grown larvæ were collected in one small area of about two square yards, such density of population being only possible if a non-cannibalistic habit is usual. As regards the feeding habits of the adult flies of *Tabanus nemocallosus* it was found that when bred females, starved under humid conditions for twenty-four hours after emergence from pupa, were allowed to bite, under cover of a test-tube, a goat whose skin had been shaven and moistened a little before they were placed to feed, all of them were observed to suck blood within five minutes; in the case of other Tabanids, various observers

have commented on the difficulty in inducing bred females to suck blood (see Patton & Cragg, *Text-book of Medical Entomology*, page 295).

Tabanus albimedius. Flies emerge about the end of February. Egg-masses of this species were observed along the river bank by the middle of March. Egg-laying is at its height thence onwards until the middle of April, whilst very few egg-masses could be found after the beginning of May. A second brood of this fly emerges about the end of June and a third brood in October, the descendants of these again appearing in February-March. These eggs are parasitized by a small chalcidid, of which 166, 78, 105 and 138 individuals emerged from four egg-masses; these parasites were bred and the life-cycle from egg to adult noted to be eight days in the case of males and nine days for females; the males, which are yellowish and smaller than the black females, thus emerge one day earlier and move about on the parasitized egg-mass in eager expectation of the emergence of the females; on this happening, coupling commences immediately and oviposition follows a few hours later. Sixty parasites were bred from one fresh egg-mass of *T. albimedius* after this had been subjected to the oviposition of one fertilized female parasite; the total number of eggs, which may be laid, may, however, be larger, as indicated by the number of parasites reared from individual egg-masses.

Egg-masses of *T. nemocallosus* were also noted to be subject to attack by a parasite of a different species, but no parasites were found in egg-masses of *T. bicallosus*.

Tabanus striatus seems to have three broods annually as in the case of *T. albimedius*, the flies emerging about the end of February, June and October.

Tabanus sanguineus, on the other hand, was not observed on the wing until the end of May, and *T. hilaris*, which is common during the Rains, also did not appear until the end of May.

Chrysops stimulans oviposits on grass growing in shallow water by a river bank during the last week in

March and during April; oviposition seems to take place only between about the hours of noon and 2 P.M. The eggs of this *Chrysops* are smaller and thinner than those of *Tabanus;* they are arranged in a single layer, forming a compact mass; the process of oviposition is almost the same as in *Tabanus.* The new-laid eggs are creamy-white, later changing to pale-brown and ultimately to fuscous; they hatch after 7 days (1-30 P.M. on 22nd March to 8 A.M. on 28th March). The larvæ, like those of *Tabanus,* wriggle out from the eggs and very soon drop into the water. The larva appears sluggish but readily shams death, by bringing together both ends of its body, even at the slightest contact of the vessel in which they were kept; this habit seems characteristic of larvæ of this genus but not of other Tabanid larvæ. The newly hatched larva is about 1 mm. long and has a white syphon-tube which as well as the last segment, is clothed with very minute hairs; all body segments, except first and last (syphon), with a pair of very small delicate bristles on lateral margin; the first body-segment has two pairs, whilst the syphon carries about three pairs apically; Gräber's organ marked by two black dots. After a week, little change is visible except that Gräber's organ is marked by two pairs of dots, posterior pair smaller. Larvæ three weeks old measured 3 mm. long by 0·7 mm. broad, and Gräber's organ had seven black dots, six paired and one single. Larvæ one month old were 5 mm. long by 0·75 mm. broad, and the whole body had developed a pattern on its surface, so that the appearance of the larvæ was quite altered; Gräber's organ had now nine black dots. The larvæ feed readily on dead earthworms and are probably cannibalistic.

Larvæ of *Gastroxides ater,* kept under observation in a small glass vessel, were not found to be cannibalistic. This species breeds in hollows in tree-trunks. The flies sometimes come into light at night (as do several species of *Tabanus*) and are perhaps nocturnal in their habit of flight.

Surra Investigation.

Mr. Patel visited Kathgodam and Bareilly in September-December 1915, to ascertain what kinds of biting flies were prevalent in the Surra Zone and to carry out transmission experiments. A full account of these has been sent to the Imperial Bacteriologist, who will (I understand) publish them with his own results; it is therefore only necessary to give here a short summary of the results attained, *viz.*:—

(1) *Tabanus albimedius* and *T. striatus* were found capable of transmitting the Surra organism, not only by an interrupted feeding, but also by complete feeding.

(2) *Tabanus albimedius* was proved to transmit Surra 24 hours after feeding on Surra-infected animal; it failed to transmit disease after a longer interval. *T. striatus*, however, was found capable of transmitting Surra (in one experiment with two flies) as long as 72 hours after feeding on an infected host.

(3) Smaller species of Tabanus (*T. sp.* near *virgo*) were tried but not found to transmit disease.

(4) *Ctenocephalus felis*, dog and cattle fleas, were found incapable of transmitting Surra.

(5) *Philœmatomyia insignis* is only capable of transmitting Surra in the case of an immediate interrupted feeding, the maximum interval (*i.e.*, between leaving an infected host and commencing to feed on a previously uninfected animal), for which positive results were obtained, being only seven minutes, although positive results were obtained by direct inoculation of abdominal contents of infected flies as long as 28 hours after feeding on a Surra-infested animal.

(6) Surra is not transmitted hereditarily to the progeny of infected females of *Tabanus striatus*, *T. albimedius*, or *Philœmatomyia insignis*

Mosquitos.

The Mosquito Campaign was continued on the Pusa Estate with considerable success, the reduction in numbers of mosquitos prevalent during the year being in marked contrast to the experience of previous years. Breeding-places were sought out and dealt with, either by filling in (hollows in trees, small puddles, etc.), removal (tin cans, pots, etc., holding rain-water), oiling (large semi-permanent pools) or the introduction of larvivorous fish (more or less permanent pools, wells, etc.). Pieces of bamboo-stem, filled with water, were also placed out in trees and in other likely situations to serve as traps for oviposition of *Stegomyia*, and regularly emptied out and replaced. The following were the principal species found breeding on the Estate during the year, *viz.*, *Anopheles fuliginosus*, *A. culicifacies*, *A. rossi*, *Culex fatigans*, *C. gelidus*, *C. sitiens*, Wied (*microannulatus*, Theo), *Tœniorhynchus tenax*, *Stegomyia scutellaris*, *S. sugens* and *S. gubernatoris*. *Pseudograbhamia maculata*, not previously noted at Pusa, was also found and reared during the progress of this work.

Eleven coloured plates, showing life-histories of mosquitos, were sent to press during the year and will be available shortly, and other plates were completed.

Mr. S. K. Sen carried out a series of experiments on the rôle of blood in the development of eggs in mosquitos, the species dealt with being *Stegomyia scutellaris* for the most part. This inquiry was still in progress at the close of the year but a preliminary report on the results attained has been written up; meanwhile, it may be noted here that, as regards *S. scutellaris*, it has been found that this species (1) may oviposit without having fed on blood, (2) may deposit as many as three batches of eggs after only one meal of blood, (3) a single fertilization will suffice for several batches of eggs.

The collection of mosquitos was rearranged and put in order during the year.

A small collection of mosquitos from Pachmarhi was named up and returned and several other small lots of mosquitos were received and identified during the year.

Flesh-Flies.

In response to a circular to Veterinary officers, a large number of specimens of maggots, causing myiasis in domestic animals, etc., have been received and the flies bred out. A parallel series of observations has been kept up on the attractiveness for various flies, especially those species breeding in septic matter, of meat treated in various ways; the substances tried included Peptone, Hydrochloric Acid, Formalin, Papain with Hydrochloric Acid, Borneol, Vanillin, Sugar, Salt, Mercurous Chloride, Benzine, Lactic Acid.

Ticks.

Specimens of *Ornithodoros savignyi*, received from Madras in 1914, and some more of the same species from Gujarat, were under observation throughout the year. A species, identical with or near *O. lahorensis*, was received from Agra. Both were fed on goats.

III. Programme of work for 1916-17.

The work which can be done will depend on the return of (1) Mr. Howlett, now on extended leave on Medical Certificate up to 28th January 1917, (2) the two Assistants sent to Mesopotamia for Fly Control work. Pending their return work must be largely of a routine character, *viz.*, care and upkeep of collections and records, breeding and observation of Tabanids, Mosquitos, Ticks, etc., continuance of Mosquito Campaign, and affording help to inquirers as far as possible.

REPORT OF THE IMPERIAL AGRICULTURAL BACTERIOLOGIST.

(C. M. Hutchinson, B.A.)

I. Administration and Tours.

Charge. I held charge of the section throughout the year excepting one month's privilege leave in September and October 1915, when Mr. N. V. Joshi was in charge.

Establishment. Mr. C. S. Ram Ayyer was on privilege leave for two months from 25th April 1916.

Mr. A. N. Bose went on privilege leave for one month and four days from 20th November 1915.

Mr. Hardayal Singh has left this section on deputation to work in the Agricultural Department, United Provinces, for two years, and Mr. Umrao Bahadur Mathur has been appointed in his place.

Tours. The following tours were made by me during the year 1915-16 :—

1. July 1915. To Calcutta to carry out experiments on the use of a new form of inoculation for rice beer in the laboratory of the Chemical Examiner, at the instance of the Assistant Commissioner of Excise for Bengal.
2. October 1915. To Shillong on hill recess.
3. November 1915. To Calcutta to consult Director General of Commercial Intelligence Department, on the subject of saltpetre industry, Messrs. Graham & Co., on the subject of manure supply and Messrs. D. Waldie & Co., Konnagar, on the subject of fermentation.
4. March 1916. To Muzafferpur to be present at a meeting of the Bihar Planters' Association.
5. April 1916. To Simla to consult the Imperial Silk Specialist, in connection with the pebrine disease investigation; to Muzafferpur to address

Bihar Planters' Association Meeting on the subject of the modified method of green-manuring.

6. May 1916. To Bakagaon, Dooriah, Motipur, Mehsi and Bara to inquire into the local methods of *nuniahs* in connection with the saltpetre industry.
7. June 1916. To Saraya, Bara and Peepra factories, in connection with work on Indigo manufacture.

II. Training.

Mr. D. V. Bal, Assistant to the Agricultural Chemist to the Government of Central Provinces, who was under training in this laboratory from 20th August 1914, finished his course on the 17th April 1916 and was allowed to return to his Province.

Mr. S. N. Bose, Bacteriological Assistant to the Agricultural Chemist to the Government of Bengal, is under training in this laboratory from 3rd January 1916.

III. Soil Bacteriology.

Toxins. Work on the lines indicated in the report of this section for the previous year was continued, but was considerably interfered with by the claims of special enquiries on various technical subjects hereinafter dealt with. Considerable progress, however, was made in collecting evidence as to the occurrence in field soils of toxins resulting from bacterial action, and of their unfavourable influence upon fertility as dependent upon nitrification and correlated bacterial processes in soil. A series of field experimental plots under wheat demonstrated the production of infertility in soil containing nitrogenous organic matter (oil-cake) as a consequence of semi-anaerobic conditions artificially induced by water-logging; this infertility did not occur to the same extent when ammonium sulphate was substituted for cake, nor did the effect of the water-logging become apparent until the roots of the plants had gone down some inches, to that level in the soil which

oxidation consequent on the cultivation, had failed to reach. Parallel plots with barley illustrated this effect more markedly than those with wheat, no doubt owing to the later formation of the secondary root system in the former crop and its consequent dependence for a longer period of its early growth upon the original deeper roots. Laboratory work on nitrification and on the growth of seedlings in water and soil cultures demonstrated the possibility of separating substances from certain bacterial cultures, from decomposing organic matter and from anaerobically incubated soil, whose toxicity to nitrifiers, and in greater concentration to seedling plants was demonstrable under these conditions.

Interesting observations were made as to the interference with the growth of seedlings resulting from the bacterial invasion of the unexhausted and still attached seed and the consequent absorption by the plant of toxic bacterial by-products. This invasion occurred most readily in water-logged soil and more especially in the presence of bacteria derived from anaerobically incubated soils of high organic matter content. Copper sulphate was found to neutralize most of the toxic bodies obtained in this way, and seeds treated with this salt were found to be immunized to some extent, although not entirely or invariably, against this action. It is suggested that some such treatment might be advantageous when sowing in wet soils, although the results of field trials have so far not yielded conclusive results, owing to the difficulties associated with its use and the unfavourable effect upon germination which copper sulphate has been found to exert in many instances.

Amongst soil toxins produced by bacterial action nitrites are well known to exert a prejudicial effect upon plant growth; it has been found that their presence in soils is not alone due to the reduction of nitrates already formed, although this is of frequent occurrence, but that in many of the soils examined in this laboratory nitrites accumulate to some extent before nitrate formation becomes evident, even under conditions apparently favourable to nitrification.

It is not clear at present whether this is due to the formation and reduction of nitrates or to incomplete oxidation consequent on the lack of activity or insufficient number of nitrate formers in the soil. Evidence is not wanting that in many of the soils examined the very slow rate of nitrification observed under optimal conditions of aeration and water content, is due to the absence in sufficient numbers or lack of physiological activity of the necessary nitrifying organisms. It will be readily realized what an important field for enquiry is opened up by this observation, which, however, in view of its wide divergence from received ideas on this subject, will require further substantiation by careful experiment and observation. The effect of nitrites on seedlings and the concentration required to produce the prejudicial results observed, was ascertained for various field crops in water culture. At the same time observations were made as to the concentration of nitrites occurring in the soil water under various conditions, but in none of the soils examined was this found to rise to the degree found toxic in water culture. It does not necessarily follow that this statical treatment of the question disposes of the possible intoxication by nitrites of plants growing in such soils, owing to the necessity for taking into account the constant formation of nitrites in the soil to replace those absorbed by the plant or oxidized in the soil, and the possibility of cumulative intoxication in the plant itself of which at present we know nothing. The presence of nitrites in soil was found to affect germination and early growth; this explained the apparently anomalous result of an experiment in which germination in a well-aerated soil compared unfavourably with that in the same soil badly supplied with air; on further examination it was found that in this soil when well aerated complete nitrification was preceded by the incomplete stage of nitrite formation and accumulation, and as this was coincident with the germination period of the seeds sown therein the germination of the latter was interfered with to a greater extent than in the soil in which no nitrification was taking place.

Weekly borings and nitrate determinations throughout the year were made in three sets of duplicate plots under grass, cold weather and rains crops (wheat and maize), and fallow respectively. Only in the last of these was there any accumulation of nitrate in the first foot of soil, a much smaller amount occurring in the cropped soil and only very small quantities under grass. Experiments will be made to ascertain whether the grass effect is due to interference with the upward movement of water resulting from evaporation from the surface, to lack of aeration, or possibly to the toxic action of the specific bacterial flora associated with the grass plants. The nitrate accumulation was highest in February and reached a minimum in August; this was only in the first foot of soil and no doubt represented the vertical movement of nitrates parallel with that of the soil water.

Green-manuring. Experiments with fermented green manure were carried out on tobacco to which fermented sann hemp (*Crotalaria juncea*) was applied. Very large increases in yield were obtained, and a Bulletin (No. 63) describing this modified method of manuring was published, inviting suggestions and criticisms from agricultural officers in the Provinces from whom many useful and appreciative communications have been received, pointing out the applicability of the method to various manurial problems and special cases in their several districts. It is hoped that the experimental trials of this method which are now being made throughout India may lead to more satisfactory and certain results from the use of green manures than are generally obtained. A field trial of the method at Pusa carried out by the Imperial Agriculturist on the *rabi* oat crop gave very high returns : the Officiating Imperial Agriculturist is carrying out a further experiment this year.

Saltpetre. The enquiry into the conditions favouring the occurrence of saltpetre in Indian soils and the methods adopted by the native for extracting it, was continued and the results published in a Bulletin.

It was concluded that the output of saltpetre is limited at present not so much by the available supply of raw material, as by the number of workers (*Nuniahs*) actually engaged in extraction, this being largely determined by the price of crude saltpetre and the restrictions imposed by landholders, refiners, and the Salt Department. No special soil organisms appear to be associated with saltpetre deposits which are the result of the nitrification of organic matter accumulated in the neighbourhood of human dwellings, the high concentrations of nitrate found in the soil in such sites being due to the upward movement of water carrying dissolved nitrates to the surface where they become concentrated by the intense evaporation going on during the dry months of the year. Experiments on a field scale showed the feasibility of adding to the store of nitrates in the country by the use of nitre beds made up by burying a green crop, in this case *Crotalaria juncea*, in ordinary field soil and compacting the heaps sufficiently to ensure the capillary rise of water from the subsoil to the surface, where the nitrate formed accumulates and can be scraped off after the manner of the *nuniah*. It is suggested that a very large output of saltpetre could be obtained in this way in those parts of India in which soils with sufficient lime content and suitable physical texture are found. At the same time the condition of the industry as a whole could be greatly improved by the introduction of better relations between the *nuniah* and refiner and a revision of the rules of the Salt Department in regard to both of them. It seems clear that the profits of the trade are not equitably divided between the *nuniah* and the refiner, the former class, in consequence of its poverty and lack of business capacity, being entirely at the mercy of the middleman or refiner to the detriment of the industry as a whole. So far as the methods of extraction and refining are concerned the work of the Chemical Section of this Institute, as described in Bulletin No. 24 by Messrs. Leather and Mukerji, has demonstrated the possibility of great improvement in the refining part of the process, and further investigation in

the writer's laboratory has shown that the *nuniah's* method of extraction of the crude saltpetre is far from being economically sound, and could be greatly improved upon by some simple variation of his present technique, which would, however, probably depend upon co-operation with the Salt Department in order to avoid infringement of the regulations at present in force. An advantage offered by the artificial method of producing saltpetre above referred to, lies in the comparative freedom from contamination by salt (sodium chloride) of the crude saltpetre resulting from this method, thus avoiding to a great extent in the process of extraction the restrictions necessarily imposed upon this process by excise requirements, with a consequently higher return of pure product to the advantage of the *nuniah* and the trade.

IV. Special Enquiries.

Fermentation Organisms. Further work on alcohol producing organisms, and upon various problems in connection with Indian distilleries was carried out at the request of the Departments of Excise in Bengal, Bihar and Orissa, Assam and Central India, and of private firms in various parts of India. Improved methods of obtaining and utilizing yeast cultures of indigenous origin were experimented with and gave promising results. The use of mixed cultures of good types of *S. cerevisiæ* of Indian origin was reported by the Commissioner of Excise for Central India to have given an increased yield of some 20 per cent. in the Nowgong Distillery, and the method of re-inoculation devised in this laboratory was found to give considerably higher yields of alcohol in the same period of time and should therefore be of value in avoiding the evil effects of the acetic fermentation which generally sets in towards the end of the process.

Numerous other problems connected with fermentation were studied, but it is clear that a good case exists for the establishment of a special laboratory in India for the investigation of such questions, both for the isolation of

good strains of yeast and for the training of distillers' assistants in their proper use.

Pebrine. At the request of Mr. Lefroy, Imperial Silk Specialist, an investigation of the conditions of incidence of this disease of silkworms in India was undertaken. The primary object of the enquiry was to determine whether the failure to avoid disease in India by using the Pasteur method of selection of disease-free "seed" is due to any inherent inapplicability of the method to Indian conditions, or merely to its improper use in this country. So far as the enquiry has proceeded it appears that both these factors come into play in Bihar and Bengal. The Pasteur method depends upon the examination of the parent moth and the rejection of eggs from those found infected; the standard method of examination devised by Pasteur and used with success in Europe but with less certainty in India, allows of microscopic examination of a drop of the fluid obtained by crushing the whole moth without distinction of parts, it being assumed that the disease producing pebrine bodies will exist in such numbers in the diseased insect at this stage of its growth as to make certain of their occurrence in any sample of the body fluids taken for examination. This, however, has not been found to be the case with the pebrine-infected moth of the multivoltine mulberry silkworm as used in this part of India. Examination in the ordinary manner in many cases has failed to find the pebrine bodies, whereas examination of the lining tissues of the intestine of the same specimens has revealed their presence, the diseased condition being subsequently confirmed by the development of pebrine in a high percentage of the larvæ reared from the eggs of the moths so affected. It is clear therefore that in India, the standard method of examination fails to eliminate all diseased eggs, and in order to be at all certain of this being done it will be necessary to alter the method and unfortunately to make it more difficult and more laborious, although not at all outside the range of capability of the class of workers at present engaged in selection. In parts of Bengal, the con-

ditions are rendered more difficult by the unalterable prejudice of the rearers against purchasing "seed" in the form of eggs, their desire to be assured of the quality of the silk to be obtained leading them to refuse to buy anything except live "seed" cocoons. This means that eggs derived from moths which have passed examination and are presumably disease free, must be hatched out and brought to maturity, at the same time going through all the chances of infection incidental to several weeks' life in artificial surroundings, the resulting cocoons possibly re-infected during maturation, being bought by the rearers and used as seed. Until this prejudice is overcome by the establishment amongst the rearers of more confidence in the rearing stations, the industry must necessarily labour under the disadvantages resulting from the chances of re-infection of the seed in the manner above described.

A further point of interest has been investigated and sufficient evidence collected to warrant a certain amount of confidence in the conclusion arrived at, namely that infection of the larvæ so far as pebrine is concerned does not take place at all after the fourth moult, with difficulty after the third moult, but with comparative ease up to this stage in the life cycle. This conclusion is necessarily only a provisional one being based on a comparatively small number of experiments, but should it be confirmed by further observation it will simplify the precautionary measures in rearing by making it possible to relax them considerably during the later stages of growth, when larger quantities of leaf and greater space are required by the worms. Incidentally it was found that the majority of the larvæ were not only able to resist infection altogether when kept under optimal conditions so far as space, air and food were concerned, but that in a large number of cases the progeny of highly pebrinized moths failed to develop disease at all, if reared under these favourable conditions, others from the same brood but in unfavourable surroundings succumbing in large numbers.

Study of the life cycle of the parasitic organisms (*Nosema Bombycis*) is being carried out; so far no marked differences have been observed between the Indian and European forms, but observations are necessarily incomplete at present.

Indigo. At the suggestion of the Indigo Research Chemist an enquiry was undertaken into the bacteriological aspects of the fermentation taking place in the indigo steeping vat. As might have been expected, many important facts in connection with the great variations in yield which are known to occur for no obvious reason were brought to light by this enquiry, which, however, has not yet proceeded far enough to afford any complete explanation of the results obtained. It is clear, however, that the success of the process of manufacture as at present carried out depends primarily upon the presence and action of specific bacteria in the steeping vat, and further that in some cases an adverse result is due to the activity and deleterious influence of others. It is a well known fact that during the earlier days of manufacture the yield of indigo is low but becomes rather suddenly higher, remaining so as long as continued use of the vats persists. Any vats not utilized at first but brought into operation later, exhibit the same phenomenon, clearly showing that the latter is not due to changes in the plant, the water, or methods of manufacture. Well attested cases have been observed of differences in yield of as much as one hundred per cent. or more between head factories and their out-works manufacturing plant grown under similar conditions of soil and climate, and it was possible in one instance to arrange to exchange indigo plant from one such factory to another, thus eliminating any possible influence of this factor, but without altering the previously observed difference in the respective yields. The most obvious conclusion seems to be that such differences are due to the presence or absence of specific bacteria which multiply in and infect the steeping vats, increasing in number and consequently in their influence upon the character of the fermentation up to the limits of the permanent

substratum (in this case the walls and floor of the vat) upon which they remain from one operation until the next; this supposition is supported by observation of the easily verified fact that fermentation commences in the immediate neighbourhood of the walls of the vat and gradually spreads therefrom toward the centre. Here we have an analogy with such functions as that of the "starter" in dairy work and the bacterial slime of the sewage filter bed, and very probably under natural conditions with the micro-organisms responsible for the retting of jute and flax. Many industries depend upon the intervention of micro-organisms, but whereas in some of them the presence of desirable species and the absence of deleterious ones is ensured by artificial measures as in the case of brewing and distilling, in others it is assumed that the proper organisms will be naturally present in sufficient predominance to ensure satisfactory results. This is the case with such native Indian industries as the fermentation of "Toddy" and "Mahua," the retting of jute and the steeping of indigo, but it is becoming daily more clear that the distribution of the necessary and proper micro-organisms is by no means so universal or so fortunate as to carry these and similar operations outside the range of practical artificial regulation.

The enquiry in connection with indigo is at present in too early a stage to warrant any confident assumption that it will be possible to apply the methods of the distillery or the dairy with economic success to a raw material such as the indigo plant, but should further work confirm the conclusions set forth above, it would appear that very considerable improvements in the methods of manufacture may be obtained by artificially ensuring the presence of the necessary organisms in the steeping vat.

It has been ascertained that two distinct types of fermentation may be found in the steeping vats, one in which copious evolution of nitrogen takes place, the only other gas given off being carbon dioxide, and the other in which

hydrogen is liberated in addition to these two. In the former case, during the factory period of fermentation, about twelve hours, nitrogen forms sometimes as much as 98 per cent. of the evolved gases, the remainder being carbon dioxide; later these proportions are slowly reversed, but this reversal is of no importance as not affecting factory conditions and requiring 48 hours to 60 hours to complete.

In the second case the evolved gases after twelve hours are composed of about equal parts, some 33 per cent. each of nitrogen, hydrogen, and carbon dioxide. It is remarkable that no trace of methane has been found in any of the numerous fermentations carried out, and it is also of great interest to note that in some instances in contradistinction to the high nitrogen evolution frequently found, very small quantities of this gas were evolved.

It is clear therefore that the character of the fermentation must be governed by that of the bacterial complex fortuitously present, and that this may vary essentially and profoundly even in contiguous localities. This variation will have a special interest and importance in connection with the decomposition of organic matter in soil under varying conditions, and must be taken into careful consideration in advancing any theories based upon observation of chemical changes due to bacterial action in soils under otherwise apparently similar conditions.

Numerous species of bacteria have been isolated in the course of this enquiry and their physiological activities with regard to the processes of fermentation investigated. It has been possible to place some of them definitely either in the class of beneficial or deleterious organisms, but much further work will have to be done before their true functions in this connection are fully understood. It is of interest to note that one bacterium has been identified with the unfortunate condition which sometimes arises in the "beating" or oxidizing process known as "green vat."

Biological analysis of soils. Numerous samples of soil from various districts were analysed by the biological

method elaborated in this laboratory. Familiarization with the use of this method forms an important part of the training of students in this section and as such students mostly come from the laboratories of Provincial Agricultural Colleges and return there as assistants to the experts engaged in soil investigation, it is hoped that in course of time the method may be adopted as a standard part of such enquiries throughout India.

V. Programme of work for 1916-17.

Major subjects.

1. The decomposition of organic matter in the soil by bacterial action.

2. The formation of toxins in soil and their relationship to fertility.

Special enquiries.

3. *Saltpetre.* Investigation into the conditions under which this salt is formed in the soil with a view to introducing possibly favourable modifications into the present methods of the *nuniah.*

4. *Fermentation.* Further inquiries with regard to fermentation organisms in India.

5. *Silk.* Pebrine disease of silkworms in India; an enquiry into the incidence and underlying causes of this disease undertaken at the request of the Imperial Silk Specialist.

6. *Indigo.* An enquiry into the bacterial activities associated with the manufacture of indigo undertaken in collaboration with the Indigo Research Chemist.

Minor subjects.

7. Bacterial disease of plants.

8. Biological analysis of soils and elaboration of laboratory technique in connection therewith.

9. Training of students.

VI. Publications.

1. Walton, J. H. . Azotobacter and Nitrogen Fixation in Indian Soils. *Memoirs of the Department of Agriculture in India, Bacteriological Series*, Vol. I, No. 4.
2. Hutchinson, C. M. and Joshi, N. V. Bacterial Rot of stored Potato Tubers. *Memoirs of the Department of Agriculture in India, Bacteriological Series*, Vol. I, No. 5.
3. Hutchinson, C. M. and Ram Ayyar, C. S. Bakhar:—The Indian Rice Beer Ferment. *Memoirs of the Department of Agriculture in India, Bacteriological Series*, Vol. I, No. 6.
4. Hutchinson, C. M. Report on Soil Bacteriology for Board of Scientific Advice, 1914-15.
5. Hutchinson, C. M. A Modified method of Green-Manuring. *Bulletin No. 63 of the Agricultural Research Institute, Pusa.*
6. Hutchinson, C. M. Saltpetre—Its origin and extraction in India. *Bulletin No. 68 of the Agricultural Research Institute, Pusa.*
7. Hutchinson, C. M. Photographic Illustration.—An article in the *Agricultural Journal of India* for July 1916.

REPORT OF THE IMPERIAL COTTON SPECIALIST.

(G. A. Gammie, F.L.S.)

I. Charge and Tours.

Charge. I held charge of the office of the Imperial Cotton Specialist throughout the year.

Tours. In addition to the special investigations which were under continuous observation, I visited Khandesh in September and October; travelled through Central India with Mr. Coventry in November; in December I toured in the Central Provinces; in April I visited the Southern Mahratta Country.

My Assistant Mr. Mankad made special researches during the year in the Southern Mahratta Country, Gujerat and the Garo and the Chittagong Hill tracts.

II. Cottons in the Provinces.

Central India.

The following report was submitted to Mr. Coventry with whom I made a tour throughout the cotton tracts of Central India :—

" Gwalior is not really a cotton tract and for the purpose of improving what little cotton there is, the trials of the following would be sufficient :—

(1) Yellow-flowered Malvensis.
(2) White-flowered Roseum.
(3) Cambodia under the control of irrigation.
(4) Leake's K 7, on account of its earliness.

" At Bhopal, white-flowered cottons do not seem to come in the mixture of varieties and the higher quality of the local cotton is due to this fact. The cotton round Bhopal, 5,000 bales, is said to be capable of spinning 20's. It has a percentage of 25, which is far too low.

" I am of opinion that the Malvensis or the Malvi cotton is really the only high class cotton of the Malva tract and if that were purified, no foreign variety could possibly surpass it in excellence.

" As regards Central India, I would recommend that the following trials should be made in as many cotton areas as possible :—

(A) For high class soils—

(1) Local Malvensis.
(2) *Bani* × *Deshi Lahore* from Sindewahi Farm.
(3) *Bhuri* from Akola. } Controlled by irriga-
(4) Cambodia from Gadag. } tion if possible.

(B) For the inferior soils of the Nimari tract—

(1) Local *roseum*.
(2) Akola *roseum*.
(3) K 7.

" From valuations received from Messrs. Tata on various cotton samples sent from the Indore Farm, the so-called local cotton is valued at Rs. 225 and is said to have no characteristic of the cotton of the district. The variety *vera* of the same farm is reported to be characteristic of the cotton of the district and is valued at Rs. 280, the market rate of the day for Indore cotton. It has fair staple, but it is inferior to the Sindewahi Crosses *Bani* × *Roseum* valued at Rs. 285, and *Bani* × *Deshi Lahore* valued at Rs. 295. I had a comparison made specially because I was in search of a better cotton for Central India. I consider that *Bani* × *Deshi Lahore* is in every way superior to Malvensis. As far as appearance goes, there is no tangible difference and the growing period is the same.

" Cambodia, wherever possible, should be started under irrigation early in the season so that it can be ripened before the severe cold weather begins. The true Malvensis of the Central Provinces has been abandoned on account of its low percentage of 32 not allowing it to compete with the coarser varieties of high percentage, but it is quite probable that *Bani* × *Deshi Lahore* will take its place."

United Provinces.

The Deputy Director of Agriculture of the Central Circle submitted for valuation samples from nine selections of acclimatized Cawnpore-American Cotton. All were grown under irrigation. The yield from these, this year, was very unfavourable, being about 560 lb. of *kapas* per acre but in good years the unselected crop gives on the farm 720 to 800 lb. per acre on a large scale and has yielded up to 1,200 lb. per acre. The ginning percentage of these selections is 31 to 33.

Messrs. Tata reported as follows on these samples :—

Basis of prices on 11th July 1916.

	Rs.
Sind-American	310
Good Sind-American	325
Madras Cambodia	365
Ordinary Cambodia	340
Saw-ginned Dharwar	320
Navasari	375
Kumpta	345
Superfine Bengal	250

Samples 1 to 9 : —

Of these No. 2 is the best in length and strength of staple, then comes No. 9, then come Nos. 1, 6, 7 and 8 which are equally long in staple but rather weak in fibre; then come Nos. 4 and 5 and No. 3 comes last.

No. 2 can spin up to 30's, value Rs. 340.
No. 9 can spin up to 24's, value Rs. 330.
Nos. 1, 6, 7 and 8 can spin up to 20's, value Rs. 325.
No. 3 can spin up to 16's, value Rs. 310.

All fibres are irregular.

Central Provinces.

The following report was submitted to the Director of Agriculture together with the remarks and the valuations of certain varieties of cottons which have recently been estimated :—

Sindewahi. Here there are a number of good selections of *rosea*. Mr. Clouston proposes to reduce these to one or two, basing the selection on ginning percentage and acreage outturn, the highest ginning percentage so far being 42.

One sample of *roseum* was reported on by Messrs. Tata & Sons as equal to Superfine Bengal, spinning up to 10's and valued at Rs. 240 per *candy*. The ginning percentage of this variety was 39·9. The outturn was 1,035 lb. seed cotton per acre, so that the actual value of this cotton per acre works out to Rs. 126-6-0.

Cambodia was ripening at the same time as *Bhuri* and not later, as is usually the case.

Messrs. Tata made the following remarks on a sample submitted to them :—

" Cambodia has greatly improved on the Chanda soil. The feel is soft, staple longer and stronger. Value Rs. 350, *i.e.*, equal to the full market value of the day. It can spin 40's." The percentage of cotton to seed was 34·8 and the outturn 534 lb. This gives an actual acreage value of the cotton, Rs. 82-15-0. Bhuri was said to be equal to the above, but with stronger staple, and it is valued at Rs. 355. The percentage was 33·7, acreage yield 492 lb., the value of the cotton being Rs. 75-1-0 per acre.

Acclimatized Allen's Hybrid from Nagpur looked well and bore a high quality of lint. No sample of the cotton was submitted for examination.

Leake's " K 7 " is a smaller type of plant than any found in the Central Provinces. It is very prolific, being covered with bolls, which are, however, of small size. The percentage of cotton to seed is 32·6, the outturn 920 lb. It is valued at Rs. 250 on account of its softness and slightly longer staple. All the varieties of this type tried in the Jari tract were valued at Rs. 235. The acreage outturn of *K 7* works out to Rs. 95-10-0.

Bani × *Deshi Lahore Cross.* This is very promising, the lint is similar to Malvensis, but the ginning percentage is 35·5 and the yield per acre, last year, was 600 lb. The

possibility of the extension of this type should be kept in view. At present the difficulty of obtaining labour sufficient to put out rice and cotton at the same time precludes the idea of any close attention being paid to cotton, which is not a crop of this tract. When the work of distributing the seed of this variety commences, I have suggested that it should bear the name of '*Sindewahi Cross.*'

Another cross *Bani* × *Roseum* is almost as good as this, but the lint is slightly harsher and coarser. Messrs. Tata & Sons report as follows of these two varieties :—

Bani × *Roseum.* The crossing seems to have improved the original type *Roseum*, the *Bani* having imparted to *Roseum* the characteristic of its staple. The fibre is very strong and the staple fairly long. We value this at Rs. 285 and it can spin up to 20's to 22's.

Bani × *Deshi Lahore.* This is superior to the last in length and silkiness. The crossing has improved the Delhi-Punjab cotton. We value it at Rs. 295. The percentage of *Bani* × *Roseum* is 36 and the yield 920 lb., giving an acreage value of Rs. 119-3-0. The percentage of *Bani* × *Deshi Lahore* is 35·5, the acreage outturn 760 lb. and the value of cotton Rs. 101-8-0.

Placed in the order of their actual outturn value, the varieties sent from the Sindewahi Farm stand as follows :—

(1) *Roseum.*
(2) *Bani* × *Roseum.*
(3) *Bani* × *Deshi Lahore.*
(4) *K 7.*
(5) *Cambodia.*
(6) *Bhuri.*

The bases of the market prices of the day on 15th February 1916 :—

	Rs.
Cambodia	350
Ghat Bani	340
Fine Akola	265
Fine Khandesh	250
Indore	280
Fine Bengal	228
Superfine Bengal	240

Nagpur. I went over the cottons on the Nagpur Farm with Mr. Graham, the Economic Botanist. He is working out an early variety suitable for introduction into the northern parts of the Central Provinces.

The tall growing variety, which I selected out for him, last year, comes quite true. Mr. Allan has discovered what appears to be wilt-resisting Neglectum and this deserves to be thoroughly tested.

Jubbalpore. The experiments here are conducted with the view of evolving a productive early variety for Seoni. The yellow-flowered Saugor Jari is preferred here, on account of its high yield. It has already been introduced into Seoni and the two cotton tracts of the Jubbalpore District. In this yellow-flowered Saugor Jari there are two types of lint, one resembling that of Malvensis, the other Vera. Mr. Graham has picked bolls of each from single plants for further test, as it is clearly necessary to make a more rigid selection of Saugor Jari than has already been done.

In *C 10* there is a distinct evidence of crossing between Jari and Mooltan. The result is promising and Mr. Graham has taken the bolls of one good plant for further test.

Powarkhera Farm. *Saugor Jari yellow-flowered.* Ginning percentage from 36 to 39. The plants were uniform on the whole, being of the Jari or Vera type, with a very slight tendency towards Malvensis.

Saugor Jari white-flowered. Ginning percentage 37 to 40. In appearance it differs a little from the preceding; but there is perhaps not such a strong tendency in the direction of Malvensis.

Aligarh white-flowered. Percentage 38 to 42. Does not appreciably differ from the white-flowered Saugor Jari, though, on the whole, the lint may be coarser; samples of cottons were supplied by the Superintendent.

Messrs. Tata report as follows on the samples sent from this Station :—

Basis of prices per candy of 784 lb. on 15th July 1916 :—

	Rs.
Berar Jari	270
Fine Bengal	240

Aligarh white-flowered. Compared with *roseum* grown on the Akola Farm is almost equal to it except that the Aligarh cotton is softer to the feel. Value Rs. 245.

Saugor Jari yellow and white-flowered are ordinary short stapled Rajputana style cotton. Value Rs. 235.

Akola Farm. Ten samples of cotton received from the Akola Station stand in the following order based on the outturn per acre and valuations made in Bombay :—

	Rs.	A.
(1) Bhuri	116	10
(2) Cutchica	104	6
(3) Roseum	100	15
(4) Bani	76	8
(5) Berar Jari	74	11
(6) Bani × Deshi Lahore	73	2
(7) Vera	57	11
(8) Malvensis	45	10
(9) Bani × Mathio	37	14
(10) Bani × Roseum	35	15

Bombay.

Jalgaon Farm. Mr. Leake's *K 7*. The plants are uniform, about 2 feet in height and fruit freely from base upwards and every plant ripens a good number of bolls. This variety came into flower on the 10th August and the picking is expected in the first week of October. The picking of the local cottons will commence in the third week of October. The cotton of *K 7* is slightly superior to that of the N. R., but the percentage is low. Owing to its early ripening it ought to be sown a fortnight later than the N. R. in order that it may not be spoiled, when ripening, by rains. This might be tried in the lighter rain-fall area of Dhulia where the crops are all in, by December.

The sample of the cotton was valued by Messrs. Tata at Rs. 235 and it was reported to be quite similar to the

cotton of N. R., which was valued Rs. 5 lower. The outturn of K 7 is 525 lb. with the percentage of 33·25 against an outturn of N. R. of 657 lb. with the percentage of 38·12.

K 7 ought to be again tested this year, but unless its percentage improves, it will not compete with N. R.

N. R. Narrow-lobed, white-flowered—a seed rate of 7 lb. per acre has given a very good stand of plants with correct spacing. The usual seed rate on the farm is 11 lb. and the cultivators give 17 to 18 lb. The whole of the cotton on this farm is N. R.

Last year, 100,000 lb. of this was distributed. This year East Khandesh alone has taken 50,000 lb. There is a variation in the percentage of this cotton grown in different tracts and this variation may be due to slight differences of soil and rainfall. Mr. Kulkarni holds that the better the soil, the higher is the percentage and Mr. Vagholkar says that the longer the growing season, the better is the lint. The average percentage on the Tapti side of cultivators' cotton is 39·5, and on the farm it is 38·1. Experience gained at Dhulia proves that this cotton may be grown seven years in succession with no deterioration in quantity or quality. In future operations, selection work should go on steadily with a view of increasing the ginning percentage. The sample of cotton was valued at Rs. 230, while cotton from the same variety in the Central Provinces was valued at Rs. 240.

The average acreage values of N. R. and K 7 are Rs. 75-0-0 and 51-2-0 respectively.

Dharwar and Gadag Farms. The following report on the inspection of cottons at Dharwar and Gadag and the valuations of the samples received from the same places was submitted to the Director of Agriculture :—

Dharwar. Broach in its 10th generation maintains the ginning percentage of 32 to 33 and its period of ripening is intermediate between Kumpta and Broach.

Three samples of Broach were submitted to Messrs. Tata & Sons for valuation, one from the newly imported seed

was valued at Rs. 360; one of the 10th generation at Rs. 345 and one of the 12th generation at Rs. 330. They remark that this shows that freshly imported seeds sown on the Dharwar Farm show good results, but as the seeds get old the cotton becomes deteriorated. (Navasari of the day quoted at Rs. 365.)

In the Broach cotton auction held at Dharwar the crop was divided into five grades based on the percentage :—

1st class	33·5
2nd class	32·5
3rd class	31·5
4th class	30·5
5th class	29·5

One sample of each was remarked on as follows by Messrs. Tata :—" All the 5 samples are almost alike having very long staple, strong fibres combined with softness and silkiness. They can all spin up to 40's; value Rs. 375 equal to the Bombay market rate of Navasari for the same day and Rs. 345 for Kumpta." Messrs. Tata suggest that the cultivation of such cottons should be encouraged as much as possible; as from the several samples they have examined they find that the cotton grown in the Dharwar District out of Navasari seed is the only cotton that shows such uniformity and maintenance of strength and length of fibre.

Kumpta. The cultivator's sample of Kumpta cotton was valued as equal to the best Kumpta cotton grown in the district. It would spin up to 30's and it is priced at Rs. 335 equal to the Bombay market rate of Kumpta on the same day.

The ordinary Kumpta of the Dharwar Farm is almost equal to the last but is a little more silky, value the same and it can also spin up to 30's.

I would suggest that at Dharwar, the testing of the generations of Broach should be continued although it is fairly obvious that they soon deteriorate in value; new seeds should be introduced and tested yearly, and special atten-

tion should be given to any admixture of varieties that may occur as there is a suspicion that Broach seed is not so pure as it was.

In Kumpta, the test for quality and quantity should be continued and in the crosses, *Kumpta Cross* No. 1340 and *Kumpta* × *Ghogari* No. 1364 should be grown on as large a scale as possible.

As the list of varieties has grown to a great length it would simplify matters if the least promising were thrown out.

Gadag Farm. A sample of Dharwar-American of the farm was valued at Rs. 320, it can spin up to 20's.

A sample from Ranibennur is superior to the former in length of staple but the cotton is thin and fluffy having more wastage; it was valued at Rs. 310.

The cultivator's sample is the worst of the lot having very short staple and dull colour. It is valued at Rs. 300 and can spin up to 12's.

Of three samples of Upland type of cottons there is very little difference. They are all bulky and good stapled cottons. Nos. 4 and 5 can spin up to 32's and No. 6 up to 20's; Nos. 4 and 5 are valued at Rs. 335 and 6 at Rs. 330.

Of the three samples of New Orleans cotton, they are all thin and inferior to Nos. 4, 5 and 6. They can spin from 18's to 20's. Value Rs. 315 for No. 7 and 310 for Nos. 8 and 9.

Allen's Hybrid selected for quality and quantity—both samples are better than ordinary Saw-ginned Dharwar-American cotton and are almost equal; they can spin up to 20's and the value is Rs. 320.

Tata's Allen's Hybrid and Allen Long Staple are superior to the last. They can spin up to 22's and the value is Rs. 335. Texas long staple selected for quality can spin up to 16's and is valued at Rs. 315; that selected for quantity can spin up to 20's and the value is Rs. 325. Boyd's Prolific is equal to good ordinary saw-ginned; can spin 16's, value Rs. 312.

The cross *Christopher* × *Culpepper* stands highest in value. It is a good long stapled cotton but slightly weak in staple. It can spin up to 24's and is valued at Rs. 345.

Improved Cook and Improved Perry have both deteriorated and have very short and weak staple. They can spin 12's, value Rs. 300.

Cambodia ordinary can spin up to 20's and is valued at Rs. 325, and Cambodia selected can spin up to 16's and is valued at Rs. 310.

In the Gadag auction sale, the Cambodia cottons were graded in five classes according to the percentage.

The following are Messrs. Tatas' valuations on samples from these lots :—

" No. 2 with a percentage of 35·5 of the 2nd class is the best. It can spin up to 24's. Value Rs. 330.

No. 1 percentage 36·5 of 1st class
No. 3 percentage 34·5 of 3rd class
No. 4 percentage 33·5 of 4th class } Can spin up to 20's. Value Rs. 320.

No. 5 percentage 32·5 of 5th class. Can spin up to 16's. Value Rs. 310."

The programme of future work should include selection of Dharwar-American for quality and yield.

There is a mixture of Dharwar-American and New Orleans throughout the tract. The latter is not so resistant to disease and climate as the former and the yield of the Dharwar-American is better. Dharwar-American gins 32 per cent. against about 29 in New Orleans. The substitution of a pure crop of Dharwar-American for the present mixture with New Orleans should be persevered with.

In Ranibennur Taluka Dharwar-American is almost pure. It seems to be very difficult to cross artificially Dharwar-American and Cambodia and only a small percentage of natural crossing occurred.

In Cambodia, care should be taken not to carry too far selection for quantity as there is a suspicion that the quality

is deteriorating. Amongst the introduced Americans Peerless with a percentage of 40 is promising, but Cook, Dickson, King's improved and Peterkin are too late for the tract.

Auction sales of Broach and Cambodia cottons at Dharwar and Gadag.

These were held on the 30th April and 14th May 1916, respectively, under the control the of the Agricultural Department.

13,000 lb. of Broach seed including 3,000 lb. fresh seed directly imported from Navasari and about the same quantity of Cambodia was distributed at the beginning of the season.

On account of war difficulties 20 per cent. of Broach seed was not utilized for sowing as the growers thought that the prices for cotton would rule low; a shortage in the area also occurred on account of a prolonged break in the rains; the standing crop in some places had therefore to be grubbed up for sowing wheat.

The season proved to be very unfavourable to the cotton crop in general and the average outturn of both the cottons stood roughly at 150 to 200 lb. per acre, on a par with the local cottons, Kumpta and Dharwar-American, which is borne out by the fact that only 4,000 *dhokadas* were received in the Dharwar market against an average of 20,000 per annum. (*Dhokada* = $\frac{1}{4}$ Naga, 1 Naga = 1,344 lb.)

488 *dhokadas* of Broach cotton and 722 of Cambodia were received at the depôts; these were arranged in classes of five different grades according to the high or low ginning percentage of lint to seed cotton.

The ginning percentage of Broach cotton ranged from 29·5 to 33·5 and that of Cambodia from 32·5 to 36·5.

At the sales Broach fetched Rs. 165 to Rs. 190 and Cambodia Rs. 195 to Rs. 220 per naga of 1,344 lb., indeed very good prices; the prices were offered on the ginning percentage as well as for quality. The quotations for Kumpta and Dharwar-American on the same day were Rs. 148 and Rs. 150, respectively.

A large quantity of Broach and Cambodia was disposed of privately by the cultivators as they could not afford to wait till the sales took place.

All the Broach cotton was purchased by Messrs. Tata & Sons and Cambodia by Messrs. Forbes, Forbes Campbell & Co. of Bombay. Both the Companies were thoroughly satisfied with the product and are anxious for the extension of these high grade cottons in this part of the Presidency and they are quite willing to purchase any quantity that is produced in the Division at rates 20 to 25 per cent. higher than those prevailing for Kumpta and Dharwar-American.

I have already expressed my views with respect to the prospects of these cottons in the Southern Division which have been fully referred to in the Annual Report of this section for 1914-15 and would wish to add the following :—

With regard to the quality of cotton, Broach and Cambodia in normal years almost equal Navasari cotton (the best cotton in India) and possess superiority in the ginning percentage over the local cottons—Kumpta and Dharwar-American.

The staple of exotics is cut in sawgins which is not a desirable thing. Messrs. Forbes, Forbes Campbell & Co. got Cambodia seed separated out under roller gins whereby the staple was thoroughly preserved.

India grows only a few varieties, which can be counted on the fingers, producing cotton capable of spinning higher counts. *Bani* in the Central Provinces and *Karungani* in the Madras Presidency are no doubt long stapled cottons but the per acre outturn and the percentage of cotton to seed are very low—factors not in their favour.

Broach and Cambodia are long stapled cottons, the fibres are strong and uniform, colour creamy white and they can spin 40's.

In some places Broach and Cambodia have established themselves. It is true that extension of these cottons can only be carried over to suitable places but so long as we can not put out on a field scale our selected Kumpta strain with

a good ginning percentage, it is desirable that the introduced cottons which have passed the experimental stage should receive support at the hands of the Department both for extension and disposal.

It does not seem to be an insurmountable difficulty to sow Broach cotton before *jowari* when the cultivators have appreciated the value of this cotton. They are shrewd people and know their interest better.

Again the Department is now well strengthened by the location of Agricultural Overseers who can efficiently manage the cotton work which falls in the months of April and May when the work in the district is slack.

Gujerat. Ahmedabad District. Messrs. Whittle & Co. complained that the cottons of this tract had deteriorated by fraudulent mixing and enquiry shows that several varieties of cotton are grown normally in this tract and that very special care will have to be taken to prevent the mixture complained of.

Surat Farm. The programme of work for next year on this farm will be as follows :

1. Unit selections of Selection 11, 1018-P.G. and 1027-A. L. F. developed after special selections will be tried on a field scale.
2. Analytical work of local cottons of Khandesh and North Gujerat.
3. Trial of typical varieties of the Presidency to test the ginning percentages.
4. Special enquiry on the cottons of the Ahmedabad District based on the information supplied by this office.

Distribution of seed of improved strains in the Surat District.

Pure farm-grown seed of improved strains is distributed in a block of six villages round about Surat which is styled as group I.

Mixture of seed of all the selected strains is distributed in four villages and is called group II.

During the year under report 27,000 lb. seed was distributed in both the groups. Owing to a prolonged drought the crop had to be grubbed up in some cases and its place taken by other crops. The actual area under improved seeds was 1,500 acres. In spite of a bad season the cultivators were satisfied with the outturn and the quality.

The scheme formulated by Mr. Bhimbhai, as president of the committee for the disposal of *kapas* of the improved strains, has been found to work extremely well and the growers are thoroughly satisfied with this arrangement. Cotton was disposed of in 5 lots and the prices realized ranged between Rs. 138 to 140 per *bhar* (924 lb.) of *kapas* against Rs. 121 to 131 of the local cotton. This means that the growers earned on an average Rs. 8 to 9 per *bhar* of *kapas* over the local cotton by growing improved strains.

It is interesting to note that a certain landlord has put out about 250 acres under improved seed (mixture of all the four strains) between Navapurpeth to Khundara on the Tapti Valley Railway where the Surat *Deshi* type is grown. The outturn and the quality of cotton satisfied the growers in spite of a bad season. During the ensuing year he proposes to extend the area and he is said to have already secured 30,000 lb. seed for the purpose. From this it may be inferred that in such tracts improved strains will find a ready market without the intervention of Government. It is possible that improved strains may find way in places like Billimora, Chikhli, etc., where there is no severe competition of markets and where new seed is hardly introduced.

Broach. The percentage of the *ghogari* type has been found to increase rapidly as a mixture in the Broach type throughout the District. Towards Jambuser and from Chamargaon northwards it is impossible to find any field pure under the Broach type. This has resulted in the loss of the reputation of Broach cotton.

On the Government Plot pure Broach and the three *ghogari* types are tested to compare the outturn and the

ginning percentage with the prevailing mixture of Broach and Ghogari. This is the first year of the trials on a field scale with the *ghogari* types and as the character of the season was very unfavourable to the cotton crop it is premature to say anything on the relative merits of these types. The outturn results and the ginning percentage of each of the three types are almost equal this year. Pure Broach compares favourably in outturn with the *ghogari* type but its ginning percentage is low, being 38 against 44 of *ghogari*. The ginning percentage of all the cotton seems to be very high this year at the expense of quality. No doubt the *ghogari* type is superior in ginning percentage but the quality of cotton is inferior; in fact, it is Bengal cotton and can never be compared with *Broach*.

Dohad. This does not come within the actual zone of the cotton-growing tract. Trials were undertaken to test the behaviour of Bhuri, Cambodia, and N. R. one of the *neglectum* types, during the last five years with the result that the former two varieties were found quite unsuitable to this tract. They grew very vigorously during the early part of the season but later on they invariably suffered from attacks of pests and were destroyed by frost (the occurrence of which is common) as they occupied the ground for a longer period. It has, however, been found that N. R. cotton is the suitable variety for the black soil area though the period of maturity is rather prolonged on account of the retentive character of the soil. The percentage of cotton to seed is low, 36 against 38 on the Jalgaon Farm whence the seed is obtained.

In N. R. cotton, some plants produce perfectly naked seed, the naked seed type has been found to possess a very low ginning percentage—35 only though the fibre is good. The plants are dwarf in size and mature two weeks earlier than the ordinary N. R. It has been proposed to try this type on a fairly large scale during the ensuing year to test both outturn and ginning percentage results.

The area under cotton in these parts will be restricted as the soils can be double cropped. There is a difficulty

also in regard to the disposal of the produce at a reasonable price as there is no market for cotton.

Now that the appointments of Agricultural Overseers have been made for this tract it is hoped that energetic measures will be taken to steadily extend the area under cotton in different parts and show to the Bhils the relative advantages of this industrial crop; at the same time they will induce the merchants of Godhra to encourage cotton cultivation by paying reasonable prices.

Bengal and Assam.

Mr. Mankad undertook a tour to study the conditions under which cotton is cultivated in the Garo and the Chittagong Hill Tracts and submitted a report which was communicated to the local officers concerned.

Valuations. As usual all the samples received were submitted to Messrs. Tata Sons & Co., Bombay, to whom cordial acknowledgment is due for their kindness and promptitude in furnishing valuations and opinions of the numerous samples.

III. Programme of work for the year 1916-17.

Major.

(1) To visit and advise on points regarding cotton and its cultivation whenever requested to do so by the Provincial Departments of Agriculture.

Minor.

(2) The study of the behaviour of Bhuri, Cambodia and other such cottons in non-cotton-producing tracts as detailed in the last year's programme, will be continued.

(3) An enquiry into the manurial requirements of cotton will be continued.

(4) Researches on the botany of cotton will be continued.

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