SCIENTIFIC REPORTS

OF THE

Agricultural Research Institute, Pusa

(Including the Report of the Imperial Cotton Specialist)

1916-17

CALCUTTA
SUPERINTENDENT GOVERNMENT PRINTING, INDIA
1917

Price 9 annas or 10d.

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REPORT OF THE DIRECTOR.

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

I. Charge and Staff.

Charge. I held charge of the office of the Agricultural Adviser to the Government of India and Director, Agricultural Research Institute, Pusa, and Mr. Wynne Sayer held the post of Assistant to the Agricultural Adviser throughout the year.

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

Major J. W. Leather, V.D., F.I.C., retired from the Indian Agricultural Service on 12th August, 1916.

Mr. Jatindra Nath Sen, Supernumerary Agricultural Chemist, acted as Imperial Agricultural Chemist up to 28th February, 1917, when he was relieved by the late Mr. J. H. Barnes. Mr. Barnes died of enteric fever on the 2nd June, 1917, after holding the post for three months only. His untimely death is a serious loss to the Institute and to the Indian Agricultural Service. Mr. Sen's services have been placed at the disposal of the Government of the United Provinces from 13th April, 1917, to carry on analytical and special medical work at the Ghazipur Opium Factory.

The appointment of Mr. W. A. Davis as Indigo Research Chemist sanctioned for one year from the 20th

May, 1916, has been extended for a further period of five years. He has also been temporarily placed in charge of the work of the Imperial Agricultural Chemist with effect from the 2nd June, 1917.

Mr. F. M. Howlett, Imperial Pathological Entomologist, was on leave during the year. Mr. T. Bainbrigge Fletcher remained in charge of the Pathological Section in addition to his own duties.

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. The special work on indigo, which is in charge of the Indigo Research Chemist, will be dealt with in a separate report.

Training. A number of post-graduate students attended the Institute during the year and short courses were given in sericulture.

In the section of Agricultural Bacteriology an Assistant from the Department of Agriculture, Bengal, continued his training.

A student was deputed by the Patiala State to undergo training in general entomology.

In the Mycological Section an Assistant deputed by the Punjab Department of Agriculture in April, 1917, is still under training.

A private student has been working on indigo since the 25th November, 1916, in the laboratory of the Indigo Research Chemist.

Besides the regular students mentioned above, the following visitors also worked in the laboratories :—

Mr. S. C. Bose, Assistant to the Mycologist, Indian Tea Association, worked for a month in the Mycological Laboratory.

Mr. Ganda Singh Cheema, M.Sc., of the Punjab Government College, Lahore, studied the fungal diseases of cotton and sugarcane crops in the

Mycological Section from the 1st to 27th June, 1917.

Mr. R. K. Parmeshwaram Pillai, Manager, Silk Farm, Trivandrum, deputed by the Travancore State for a course in sericulture, has been under training from the 16th February, 1917.

Six students took the short course in sericulture during the year. Two of these completed their training.

III. Publications.

The Agricultural Journal of India, Scientific Memoirs and Bulletins continued to be issued during the year. The Department published during the year 11 Memoirs and 11 Bulletins; 7 Memoirs, a similar number of Bulletins, and the Proceedings of the Mycological and Entomological Conference (1917) are in the press. A Guide to the Agricultural Section of the Pusa Institute and a booklet on the Importance of Bacterial Action in Indigo Manufacture were also issued during the year. A Bulletin (No. 75) on the Pebrine Disease of Silkworms in India has been extensively distributed free to silkworm rearers and those interested in sericulture in India. It recommends a modification of the Pasteur method which, as used hitherto in India, has failed to eliminate the pebrine disease, one of the principal causes of the decline of the Indian silk industry. It is gratifying to note a steadily increasing demand from the public for the bulletins and as a result it was necessary to reprint during the year the bulletins on Sericulture and on Soil Ventilation and Soil Erosion.

A special number of the Agricultural Journal of India was issued including papers read at the Agricultural Section of the Fourth Indian Science Congress held at Bangalore in January, 1917.

The grant of Rs. 29,000 permanently sanctioned for publications was continued during the year under report. The Publication Section has been reorganized and strengthened.

The form of the Agricultural Journal has been considerably altered and it is hoped that as a result it will gain in popularity.

IV. General Administration.

Administration. Subject to the general control of the Government of India the administration of the Pusa Research Institute is vested in the Director, but the control of the purely scientific work of the Institute (including experimental research work in the field and the publication of scientific papers) is vested in a Council of the Experts with the Director as President. The constitution of the Council was revised during the year and meetings are held at regular intervals.

Buildings and Works. The four clerks' quarters referred to in the last year's report were completed during the year. A set of experimental indigo vats have been constructed. The Government of India have sanctioned the construction of a rest house for Indian visitors and the work will be undertaken as soon as funds are available. The cost of repairs to the many old *kutcha* buildings on the estate is annually increasing and steps are shortly to be taken to demolish the majority as past repair.

With a view to improve the timber of the Pusa estate, the avenues have been carefully thinned and felling of diseased and dead trees and the planting of *sissoo* (*Dalbergia Sissoo*) and teak seedlings is being systematically carried out. Nurseries have also been put down for replacements. The disused land in the building area is being brought under cultivation. The scheme for improvement of the general drainage of Pusa is being proceeded with. Among other minor works and repairs carried out on the estate during the year may be mentioned the construction of two new gates and the improvement of ghat approaches.

The station service vehicles travelled roughly 10,500 miles during the year.

Library. In addition to the numerous bulletins, memoirs, reports, etc., which are received in exchange from

India as well as from different parts of the world, about 325 new volumes were purchased for the library during the year under report. The work of rearranging, classifying and indexing books, periodicals, etc., has been undertaken and is being proceeded with steadily. Index slips of the periodicals were also supplied to the Education Department of the Government of India for the preparation of a General Catalogue of Scientific Literature in the Libraries in India.

Pusa Schools. The total number of pupils attending the Pusa High School on the 31st March, 1917, was 221 against 193 last year. Sixteen candidates have been sent up for the Matriculation Examination of 1917.

The Lower Primary Girls' School was open for about three months, but on the resignation of the school mistress no substitute was appointed, and the school had to remain closed during the latter part of the year.

General Health of the Station. The epidemics of cholera, plague and small-pox, which broke out in the vicinity of Pusa during the months March to June, 1917, and the occurrence of four imported cases of small-pox and two of cholera among the menials coming from the affected villages seriously threatened the health of the station. By cutting off the station from all connection with the affected villages and by keeping the water supply pure, the epidemics were successfully kept out of the station and the general health continued to be good during the year under report. There was, however, one case of enteric fever among the Europeans which unfortunately proved fatal.

A female ward, properly furnished, was added to the Pusa Hospital during the year.

Medical relief was afforded to 11,956 persons of whom 11,659 were treated in the out-patients' department and 297 as indoor patients. One hundred and one cases among the European officers and their families were attended to.

Five deaths occurred in the hospital, but most of the cases were brought into the hospital in rather advanced stages of disease.

V. Accounts.

The total expenditure during the financial year 1916-17 was Rs. 5,18,603, as under :—

	Rs.
Office of the Agricultural Adviser to the Government of India and Director of the Institute	2,18,767
Chemical Section	24,639
Mycological Section	43,221
Entomological Section	41,935
Pathological Entomological Section	10,468
Bacteriological Section	30,571
Botanical Section	45,068
Agricultural Section	69,122
Indigo Research Section	34,812
Total	5,18,603

A sum of Rs. 13,620 was spent from the budget of this Department in 1916-17 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 threshing machine for the Pusa farm	5,888
Cost of anti-rinderpest serum	754
Grant to the Imperial Cotton Specialist for experimental cotton cultivation	1,500
Pay of a Veterinary Assistant in connection with cattle-breeding and of a Fieldman for mosquito experiments	1,036

The gross receipts during the year from the sale of farm produce, milk, publications of the Department and other

articles amounted to Rs 17,878 as against Rs. 15,340 in the previous year.

VI. Conferences.

In accordance with the proposal of the Government of India to adopt the policy of Sectional Meetings in years in which a full Meeting of the Board of Agriculture is not held a conference of Mycologists and Entomologists was held at Pusa on the 5th February, 1917, and following days. The session was a great success and was attended by representatives of nearly all provinces and the officers of the Indian Tea Association and Mysore State.

VII. Visitors.

No fewer than 136 persons visited the Institute during the year under report. Amongst the visitors were :—

His Honour Sir Edward Gait, Lieutenant-Governor of Bihar and Orissa; the Hon'ble Sir Claude Hill, Member-in-charge of the Department of Revenue and Agriculture, Government of India; Sir Thomas Holland, Sir R. N. Mukherji, the Hon'ble Pandit Madan Mohan Malaviya and other members of the Indian Industrial Commission, Sir George Sutherland, of Messrs. Begg Dunlop & Co., the Hon'ble Mr. W. Maude, Member of the Executive Council, Bihar and Orissa; General Gamble, Inspector-General of Volunteers; the Hon'ble Mr. L. F. Morshead, Commissioner, Tirhoot Division, Mr. J. F. Connolly, Commissioner, Northern India Salt Department; Mr. Puran Singh, Chemical Adviser, Forest Research Institute and College, Dehra Dun; and Thakur Jagannath Baksh Singh, Estate Rahwan, District Rai Bareli (United Provinces).

A party of 25 members of the Bihar Planters' Association paid a two days' visit in February, 1917. Mr. William Bembower, of the Ewing Christian College, Allahabad, with 16 students of his college, visited the Institute in March.

REPORT OF THE IMPERIAL AGRICULTURIST.

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

I. Charge and Staff.

Charge. I held charge of the post of Imperial Agriculturist during the whole period under review.

Staff. Mr. Deoki Nandan, B.A., M.R.A.C. (Cirencester), was appointed as Assistant to the Imperial Agriculturist on the 1st December, 1916. The First Farm Overseer, Mr. Ikramuddin (with two months' privilege leave), the Second Farm Overseer, Mr. Arjan Singh (with one and a half months' privilege leave), and Mr. Judah Hyam, Veterinary Overseer, remained as last year. Mr. Joseph, the Second Veterinary Overseer, was on military duty in Mesopotamia for four and a half months (from 7th July to 19th December, 1916), assisting in the fly campaign under Mr. Lefroy.

Touring. A tour was made through the North-West Frontier Province and one through the Punjab to see the headquarter station of the Department and the American cotton operations, also the salt lands of the Montgomery District. Also a tour was carried out in Sind when a number of problems connected with the proposed new Indus barrage and irrigation problems were discussed with local officers.

II. Pusa Farm.

A large part of the work of the Imperial Agriculturist consists in the management of the Pusa Farm, in fact the Madras and Bombay press critics of the last annual report stated that the Imperial Agriculturist was simply a farm bailiff. It is possible that, in the early stages of the development of Pusa, the Agricultural Section was overshadowed by the purely scientific sections and much of the energy of the Section had to be expended in preparation and bringing into cultivation of the estate and in other general

work for the common good. It is now possible, however, to carry out the purely agricultural work separately, and it is proposed to work the greater part of the farm on a purely commercial basis and give figures of profit and loss. The demonstration of the working of a large general farm on modern lines with up-to-date machinery is of the utmost importance. Scientific research must be translated into agricultural practice, and agricultural technique for large holdings has seldom due importance attached to it in India. Non-agricultural work such as conservancy, roads and sectional buildings, etc., has been put under the Assistant to the Agricultural Adviser, so the results of the purely agricultural work will not be complicated with extraneous matter.

The results of the farm work are capable of general application to many parts of the non-irrigated tracts of India, but a similar area on one of the large irrigation canals would be necessary for production of results applicable to all India.

Area. The arable area is about 400 acres and grazing about 100 acres. Outside the protective bund, there is 400 acres of rough grazing ground; this is frequently under water for two months or longer.

Rotation. The arable land, with the exception of one field of 40 acres reserved for experimental work and one field for miscellaneous crops for the various Sections, is being cropped with the following rotation :—

	1st year	2nd year	3rd year
Hot weather	Maize for silage and fodder	Maize for corn .	Pulse, green crop
Cold weather	Oats . .	*Arhar* (*Cajanus indicus*)	Oats

One-third of the total area will be manured each year with 10 tons farmyard manure to the acre, and one-third with superphosphate. This rotation will produce both fodder and grain for the large number of live stock at Pusa.

The only exceptions to the ordinary rotation crops are sugarcane and jute; these take the place of the 1st year's and 2nd year's rotations respectively. They are sown early in the season and the moisture conserved in the cold weather by repeated cultivation of the soil; this has to be done for all hot weather crops which are sown before the break of the monsoon in the beginning of June.

Working. After the *rabi* (Winter) crops are cut the land is lightly stirred by steam disc harrow or grubber, then the steam plough is given, the land being well turned to a depth of nine inches. When the first rains break in June the grubber and *hanga* (roller) are put on the land. The *kharif* (Summer) crops are drilled on that at 2-2½ feet apart and kept well inter-cultured by bullock hoes. The silage crops are ready from mid-August and silage making goes on for 4 weeks or so. Brick silos and earth silos sunk in ground are used. A power-driven shredder and elevator cut and make the silage. In October the maize cobs are picked and stored on shelves. Thereafter the cold weather crops are sown after the land has been well worked by steam grubbing and cross grubbing.

The oats are drilled with a 10-row English drill and if possible finished before the middle of November. Harvest begins in March : a large 4′ 6″ Marshall's threshing machine fitted with feeder and straw elevator deals expeditiously with all the grain.

Financial results in past year. The easiest method to get a clear and compact view of the financial results of the farm is to take the produce of the farm as passed over the farm weighbridge and compare with budget cost of running the farm. Rent, rates and taxes are not included, nor interest on capital, the salaries of the higher posts can be written off against the experimental work. Current additions to buildings, dead stock and implements are put against depreciation. The dairy herd is kept as a separate establishment and will be dealt with later.

The produce of the farm is used for :—

(*i*) The up-keep of the dairy herd,

(*ii*) The up-keep of the farm work cattle,

(*iii*) The up-keep of Estate and Botanical Area work cattle and mules.

During the season farm produce was as follows :—

	Maunds standard	@	Total
		Rs. As.	Rs.
Grain			
Oats	3,700	2 8	9,250
Maize	800	2 8	2,000
Peas	700	3 0	2,100
Wheat	300	4 0	1,200
Miscellaneous	300	3 0	900
Total	5,800	..	15,450
Green Fodder			
Chiefly maize, oats and peas	21,800	0 4	5,450
Silage, etc.			
Maize and jowar	14,000	0 6	5,250
Oat straw	10,400	0 4	2,600
Sugarcane	3,900	0 6	1,450
Total	..	..	30,200

The cost of working the farm was as follows :—

	Rs.
Cultivation	10,700
Clearing and levelling	2,500
Building and machinery	5,200
Workshop	1,100
Implements, etc.	1,200
Petty repairs and supplies	1,800
Establishment	1,600
Total	24,100

From this has to be deducted the value of one portable engine, one set of cables for tackle and a few other items, total Rs. 5,000.

	Rs.
Cost of working farm	19,100
Value of return	30,200
A profit of	11,100

When the costs of rent, rates and taxes, interest on previous capital expenditure on buildings, equipment and stock, etc., are deducted the balance will still represent a very handsome percentage return on the money spent by Government. The farm, having been well managed in the past, could well afford to be valued at an increased capital value owing to accumulated fertility.

Experimental Work. One field, "Punjabi," has been devoted to experimental work. The area is 40 acres and is divided into 124 plots of a quarter of an acre each and it is enclosed in a wire fence.

The plots have been uniformly cropped under oats for two seasons in order that series of similar plots may be selected for quantitative experimental work. It has been clearly demonstrated at Pusa that field experiment work on untested plots is useless. At present there exists the series of permanent manurial and rotational plots laid down by the Board of Agriculture 8 years ago. Results up to date show the profitableness of manuring with superphosphate combined with green-manuring. Another series is concerned with green manure fermented and applied according to the system evolved by the Imperial Agricultural Bacteriologist. The new experimental work to begin from the present year consists of—

I. *Chilli "Die back" series* for the purpose of finding a method of dealing with *Die back* (wilt) in the chilli crop. Widespread damage has been done by the disease and several methods suggested by the Mycological Department are being tried.

II. *Wheat varieties.* A selection of the most widely-known varieties recently introduced are being carefully tested under practical agricultural conditions.

III. *Pulse varieties.* A number of the most suitable leguminous crops for rotation and for green fodder for cattle are being tested.

IV. *Indigo series.* This consists in manurial and cultural tests on Java and Sumatrana indigo in consultation with the Indigo Research Chemist.

V. *Green manuring.* A new series to replace the old one has been evolved in collaboration with the Imperial Agricultural Bacteriologist.

Buildings, Machinery and Implements. The farm buildings at Pusa need a considerable amount of alteration and addition. Some of the ancient buildings of the old Remount Farm are still in use. The main block of farm buildings is badly congested with old godowns, etc., and new buildings such as Dutch barns, etc., are required. The cattle lines are old horse lines. During the year a beginning has been made in taking down some old buildings; the timber from these has been used for making an implement shed $84' \times 25'$ which was urgently required. Some old indigo vats were demolished and the bricks used for roads and putting a *pucca* floor on the cattle lines. The work cattle were brought under one roof, and the milk cattle lines have been improved by removing cross walls and knocking out windows. A wash house fitted with a steam boiler was finished for dealing with the milk vessels.

When money is available modern brick and steel buildings will have to be erected. Most of the produce of the farm such as straw, etc., is at present stored in *kutcha* bamboo buildings which, though cheap in first cost, are decidedly nasty in many ways and are not in keeping with the dignity of the premier agricultural station of India.

Among the main equipment of the farm are the following :—

Steam Plough Tackle. This consists of 2 single cylinder K class Fowler engines and a disc plough, a disc harrow, a grubber, a zig-zag harrow and a roller. The set

did invaluable work during the year. The cost for the year was—

	Rs.
Labour	1,233
Coal	1,788
Oil	300
Miscellaneous stores, etc., and renewals	713
TOTAL	4,034

No allowance is made for interest or depreciation.

	Total acres in season	Cost per acre	Best day's work
		Rs. A. P.	Acres
Ploughing	267	4 6 2	7
Harrowing	498	2 0 9	18
Grubbing	1,080	1 7 4	25
Zig-Zig Harrowing	41	0 14 9	27
Rolling	320	1 5 6	22

The tackle worked 151 days in the year.

Power Machinery. Two portable steam engines are kept employed on various works such as pumping drainage water when the river is in flood, in threshing and in silage making. Chaff cutter, grinding mill and cake breaker and the workshop machinery are driven by electric current from the estate power house.

Silage making and threshing are big items in the year's works. An "Ohio" American shredder is used to cut up the maize and the stuff is carried by elevator either into the *pucca* silos or pits. The *kutcha* pits are more successful than the *pucca* silos. There is less waste and a tight cover can be put on the top with plastered earth.

Threshing is done with a 4′ 6″ Marshall's machine fitted with feeder and elevator. The best day's work done was 427 maunds of oats.

Implements. The chief cultivation implements in use on the farm are the " Punjab plough," price Rs. 27, and the Spring-toothed Harrow made by Wallace Bros. As the fields are large nearly all crops are drilled 2-2½ feet apart with the exception of cold weather cereals. The system of interculture with bullock-drawn hoes is a great saving of labour. The cereals are drilled with a 10-coulter " English drill " and very straight work can be done.

After rain the surface of the soil is kept broken up when required by Wallace's horse hoes, chain and toothed harrows.

A good deal of work has been done in levelling up low places in the fields with a new form of scraper, adapted by the writer. An account of this and a simple wooden plough very useful for rough work has been prepared as a bulletin. Five scrapers with two ploughs working in front of them levelled 17 acres of some very rough rice land at Pusa in 45 days.

III. Farm Cropping.

Maize. Maize is sown for silage and cutting green and also for grain. The local variety is used. Trials with American varieties have not been very successful. Thirty to forty acres are sown in February in land which has been well cultivated in the cold weather to conserve moisture, and this is cut and fed to the cattle, beginning in the middle of May. The main sowing occurs after the rains in June. Trials are being made with *jowar* (*Sorghum vulgare*) sown very thickly as a substitute for maize. When sown like maize the yield is greater but there is waste with woody stalks.

The maize for cobs has *arhar* (*Cajanus indicus*) sown along with it in the drill, this occupies the ground in the cold weather after the maize has been cut out.

In " Chandman " field, 17 acres of maize yielded 323 maunds of silage per acre; cost per acre of growing was nearly Rs. 20 and return Rs. 121.

In " Nepali " field of 22 acres, maize grain came to 10 maunds with 20 maunds of stalk, *arhar* grain came to 14 maunds. Cost of cultivation was Rs. 18 per acre and return Rs. 71.

Oats. Oats are the chief cold weather cereal crop. Bihar oats are probably the best quality grown in India. In the present season the straw was short, especially in fields sown later than the first week in November. It was not possible to get on to some of the fields in good time owing to severe flooding of the farm consequent on the bursting of a large Public Works Department bund.

Two hundred and twenty-four acres of oats were sown, the average out-turn was 17 maunds per acre and $1\frac{1}{4}$ tons of straw. One or two of the flooded fields brought the average down. Fifteen acres in South Punjabi field averaged 29 maunds of grain per acre.

The oat straw is very good fodder and can be fed without chopping.

Pulses. *Arhar* and field peas are both useful rotation cold weather crops. The former is convenient as it has not to be sown at a busy time in October-November, but the yield of grain is less than the peas and the pea straw is useful fodder. Oats and peas cut green gave a yield of over 300 maunds per acre and made excellent fodder for dairy cattle.

For the hot weather a pulse crop for grazing which will keep the ground well covered during the rains is a great desideratum. Fallow ground unless it is high is very difficult to keep clean during the rains. If the water stagnates it is not possible to work it and it becomes a mass of weeds. The pulses being tried for this purpose are cow peas, soy bean, velvet bean, *guar* (*Cyamopsis psoralioides*) and a few others.

Jute and Sugarcane. A quantity of jute is grown for seed by arrangement with the Fibre Expert to the Government of Bengal. It is a useful crop for low ground which is liable to be flooded.

A number of sugarcane varieties are grown on the farm without irrigation. These varieties have mostly been for-

warded for trial by Dr. Barber, Government Sugarcane Expert, Madras. The main crop consists of red and white *Sathi* thick canes. The canes were sold to a factory at 6 annas per maund. In the area sown during the past year cost of cultivation was Rs. 27 per acre and return Rs. 76.

Berseem. A small trial showed that when irrigation was available, this valuable cold weather crop will flourish in Bihar. Around "chars" or depressions when water remains all the year round, its cultivation would be simple. If seed is available in the present year it is proposed to sow some of the "dab" land at Pusa and irrigate from the river. If this be done it would be possible to increase the number of live stock on the farm considerably.

IV. Cattle Breeding.

The breeding herd consists of two separate sections, first, a pure-bred pedigree herd of Montgomery cattle started some 10 years ago, and second, a cross-bred herd formed by putting some of the poorer milking Montgomery cows to imported Ayrshire bulls. There are some excellent strains in the pure-bred herd; the following are some of the best performances during the past season :—

Serial No.	Name of cow	Total yield of milk
		lb.
1	Imani	6,200
2	Jardi	4,978
3	Bhadki	4,906
4	Roomali	4,882
5	Kaveri	4,786

A good deal of weeding out is required but the results on the whole are good. It cannot be said that Montgomery cattle deteriorate when bred in the eastern plains of India. The herd is divided into 5 divisions each of which has a separate bull. In this way it will not be necessary to bring

in outside blood for some time, and eventually it will be possible to move one or more of these divisions to new districts as the nuclei of new pedigree herds which can be worked in connection with Pusa.

The castrated male stock have turned out to be excellent draught bullocks being hardy, 'blocky' animals, standing close to the ground.

The cross-breeding work was started over 3 years ago, so no results are yet available as to the effect of the cross on the milk yield. It is expected that not only the milk yield will be increased but also that the cows will calve more regularly and that it will be possible to wean the calves. It is intended to use cross-bred bulls on the cross-bred cows and not pure Ayrshires. There are at present two imported Ayrshire bulls, Lessnessock Wildfire and Carston Royal Scotch. They want great care to bring them through the rains.

The sole test of inclusion in the herd is the milk pail, points of colour, etc., are not considered.

As a rule the establishment of a pedigree herd is an expensive undertaking, but while the potential capital value of the Pusa herd is very great the actual cost to Government is not large. The herd consists of 125 cows, 10 bulls and 206 young stock. The cost, which would be wiped out many times by the increase of the capital value of the herd, was as follows during the year :—

Returns

	Rs.
Received for sale of milk	6,540
25 young bullocks transferred to work cattle .	1,500
27 head sold at cattle auction . . .	866
13 miscellaneous head, mostly cast . .	425
1 cross-bred bull given to Department of Agriculture, Bihar and Orissa . .	100
TOTAL .	9,431

Cost

	Rs.
Budget head for up-keep of dairy herd including all labour, etc. . . .	3,000
Food due to farm. 3,000 maunds of grain, miscellaneous, at Rs. 2-8-0 . . .	7,500
Food due to farm. Green fodder, silage and *bhusa*, 18,000 maunds at 4 annas per maund	4,500
TOTAL .	15,000

That is to say, it cost about Rs. 5,000 last year to carry on the Pusa dairy herd. Considering the huge sums spent by Governments and private agency in other parts of the world on systematic cattle breeding this is not an excessive amount.

The milk is sold direct from the cows and as the customers send their tins to the dairy the milk is not handled at all. It is sold at 10 "Lahori seers" to the rupee or about six pence per gallon.

The feeding of the cattle is done almost entirely with farm produce. At the beginning of the year the long fodder consists of silage and oat *bhusa*, about February green oats and peas are ready for cutting; towards the end of March silage and oat straw are used till mid-May when the early sown maize is ready. The season is carried on with maize and pulses till the end of October when silage is again used.

The grain used is chiefly oats with maize, *arhar*, peas, etc., well ground and fed moistened.

It is proposed to have a public cattle auction sale at least once a year for disposal of all surplus stock. As the sale will be well advertised, people needing cattle will be able to make their arrangements beforehand.

The buildings of the herd are the relics of the old horse-breeding days. They have been made as sanitary as possible but some modern buildings are needed.

V. Training.

The following students received a general practical course in agriculture :—

1. Mr. Piyarey Lal Garg, from United Provinces Agricultural College, from 7th December, 1915, to 30th September, 1916.
2. Mr. Deoki Nandan, from Bharatpur State, from 11th March to 30th November, 1916.

VI. Seed Distribution, Visitors, and Demonstration.

During the year a considerable amount of seed was distributed, among other lots 170 maunds seed oats.

A large number of visitors went round the Section, particulars are mentioned elsewhere. Members of the Bihar Planters' Association visited the farm and a special programme was arranged for the day.

VII. Publications and Correspondence.

One bulletin on "Berseem" and one on "New Implements for India" were written; a Guide book to the Agricultural Section at Pusa and a number of notes for the Agricultural Journal were also written during the year. Evidence was given before the Indian Industrial Commission chiefly on the subject of cotton.

A large number of letters of advice on various agricultural subjects were sent out.

VIII. Programme for 1917-18.

I. Practical treatment of pedigree dairy herd of Indian cattle and pedigree dairy herd of cross Montgomery-Ayrshire cattle.

II. Practical treatment of 1,200 acre mixed farm, with particular attention to profitable modern machinery and the financial results of the work.

The bulk of the produce of the farm is used for the up-keep of the dairy herd. The rotation adopted aims at the up-keep of the fertility of the land along with supply of

concentrated food and long fodder and a constant supply of green fodder throughout the year. Included in the above is the study on a practical scale of—

(*a*) Rotations,
(*b*) Crops for fodder and silage,
(*c*) Implements and machinery,
(*d*) Technique of cultural operations,
(*e*) Types of farm buildings.

III. *Experimental Work at Pusa.* After the preliminary testing of the new experimental area at Pusa, the following will be started and continued along with existing work :—

(*a*) Rotational experiments.
(*b*) Trial of new varieties of existing crops especially leguminous fodder crops, American maizes, foreign oats, and wheat varieties.
(*c*) Manurial experiments, especially seasonal and quantitative tests with phosphates.
(*d*) Rotation and manurial experiments already started.
(*e*) Seasonal and cultural tests with Java and Sumatrana indigo.
(*f*) Fermented green-manuring experiments in collaboration with the Imperial Agricultural Bacteriologist.
(*g*) Trial of sugarcane varieties suitable for growth without irrigation. Some of Dr. Barber's varieties are very promising.

IV. *Demonstrations, exhibitions and cattle sales of* surplus dairy stock, etc., will be held from time to time as occasion offers.

V. *Touring and Advisory.* Visits will be paid to provincial agricultural centres. This should tend towards co-ordination of agricultural work.

VI. *Extension of berseem cultivation.* Seed of this most promising fodder crop will be obtained and distributed in suitable districts.

REPORT OF THE IMPERIAL AGRICULTURAL CHEMIST.

(W. A. Davis, A.C.G.I., B.Sc., F.C.S., in charge.)

I. Administration and Tours.

Charge. The Section was in charge of Mr. J. Sen, M.A., F.C.S., Supernumerary Agricultural Chemist, up to February 28th, 1917, when the late Mr. J. H. Barnes, B.Sc., F.I.C., F.C.S., Imperial Agricultural Chemist, took over charge. Mr. Barnes' untimely death on June 2nd after having served at Pusa only three months will be felt as a great loss not only to the Chemical Section but to Indian agriculture and Indian science. Since 2nd June I have been temporarily in charge of the Section in addition to my duties as Indigo Research Chemist.

Establishment. The services of Mr. J. Sen have been placed at the disposal of the Government of the United Provinces with effect from April 13th to carry out special work at the Ghazipur Opium Factory.

Mr. Bhailal M. Amin, Third Assistant, has been on deputation to the Indigo Research Section from 15th June, 1916. Mr. S. K. Dutt, Eighth Assistant, was transferred to the same Section from 4th January, 1917.

Tours. Mr. Sen went to Cawnpore in September, 1916, to confer with the Deputy Director of Agriculture, Central Circle, United Provinces, on the question of drain-gauge work at Cawnpore and Pusa, and the occurrence of nitrates and alkali salts in soils. A visit was paid to Juhi to witness the reclamation work being carried out there.

In December Mr. Sen visited Cuttack to arrange for collection of soils there and in January attended a meeting of the Bihar Planters' Association.

Mr. Barnes in March went to Sabour to examine the diploma candidates in Chemistry and also visited Calcutta to discuss with the Professor of Chemistry in the

Government Presidency College the question of attracting students to Pusa for research work.

In April Mr. Barnes made a tour in the Punjab, visiting Lyallpur and Lahore. At Lyallpur he settled the details of the work to be done on canal seepage and at Lahore attended two conferences, one on the problem of canal seepage and water-logging in the Punjab and the other on the reclamation of saline barren land on the Lower Bari Doab Canal.

II. Meteorology and Drain-gauges.

The work referred to in last year's report has been continued. Waters and crops from the Cawnpore drain-gauges are also being analysed as usual for the United Provinces Department of Agriculture.

III. General analytical work and assistance given to other Sections.

Eighty-six soils have been analysed this year from different sources, 19 samples of manure or materials proposed as manures, 75 samples of feeding stuffs and 34 samples of water. Amongst the materials proposed as manure were spent *mohua* (*Bassia latifolia*) flower and the ash obtained by burning the waste tobacco butts from tobacco factories.

Two samples of *shaftal* (*Trifolium resupinatum*) hay which had been reported as giving rise to cases of poisoning were examined for the Imperial Economic Botanist, no poisonous alkaloid or cyanogenetic glucoside could be detected.

A sample of olive fruit from a Mediterranean variety grown at Taru was analysed and found to contain a high content of oil. A sample of *ajwan* (*Carum copticum*) residue, obtained in the manufacture of thymol, was analysed, the results pointed to the possibility of this residue being used either as a cattle food or manure. Actual trials to utilize this substance are in progress.

In addition to the above work assistance has been rendered to the following Sections :—

(1) *Indigo Research Section.* A large number of soils taken from fields on indigo estates in Bihar, United Provinces and Assam have been analysed in connection with the manurial requirements of these estates (see under *Soils* below) especially as regards the deficiency of available phosphate.

(2) *Bacteriological Section.* Samples of nitrates and nitrate liquors were analysed and analyses made of the gases evolved during fermentation of indigo.

(3) *Entomological Section.* Samples of mulberry leaves, etc., were analysed.

(4) *Agricultural Section.* Analyses were made of standing crops of cane in the various fields, manures, etc.

(5) *Botanical Section.* Samples of feeding stuffs and soils were analysed.

Methods of analysis. Several newly proposed methods of analysis have been tested during the year. The method proposed by Ajon of estimating potassium volumetrically by precipitating as bitartrate and subsequently titrating with alkali was found to give unreliable results, the error being about 2 per cent., the perchlorate method as modified by Davis still remaining the most convenient and most accurate method.

The Bertrand method of estimating sugars, using permanganate has been tested and found to give results often 5 per cent. in error as recently stated by Davis and Daish; its use at Pusa has therefore been discontinued, Brown and Morris' methods as modified by Davis and Daish being introduced.

IV. Soils and Nutritive Value of Crops.

A systematic series of analyses is being made of the soils of the indigo estates in Bihar. The results so far

obtained confirm the view expressed by the Indigo Research Chemist in a recent paper (*Agricultural Journal of India,* Indian Science Congress Number, 1917, p. 77) that the soils of Bihar are extraordinarily deficient in available phosphate, and that their practical depletion of such an essential constituent necessitates systematic manuring with superphosphate if the yield of crops is to be maintained. The effect of this deficiency on the quality and yield of other crops is discussed in the paper referred to and its risk of causing malnutrition and endemic disease in cattle and man. It is also suggested that this deficiency is related to the poor quality of native cattle, the low milk yield from buffaloes in Bihar, and nervous diseases such as *kumri* and defective bone formation in horses in Bengal and Bihar.

The analyses of rices grown in Bihar published by Mr. Sen in *Pusa Bulletin No. 62,* show that they are actually seriously deficient in phosphoric acid as compared with rices grown on soils richer in this constituent.

In connection with the determination of the available phosphate in soils Mr. Sen has carried out a series of experiments which show that the addition of calcium carbonate to a soil giving high values for available phosphate by Dyer's method has a great effect in diminishing the values determined by this method. This is doubtless due to the partial neutralization of the 1 per cent. citric acid used in Dyer's method. The low values obtained for available phosphate in Bihar soils is no doubt also due in part to this cause, as these soils contain abnormally large amounts of calcium carbonate, frequently amounting to 30 or 40 per cent. It must not be concluded, however, that the citric acid method does not remain an extremely useful diagnostic indication of the needs of such soils. In fact it is well known that manurial recommendations based on Dyer's method give the best results in practice in the case of calcareous soils such as those of Rothamsted, where the relative productivity of the soils agrees closely with the determinations of the available constituents by Dyer's

method. The citric acid still gives good diagnostic indications in such cases because the presence of calcium carbonate which lowers the values of available phosphate and potash in the analysis, also interferes with the action of the soil acids in bringing insoluble phosphate and potash into a soluble form suitable to serve as plant food. In Bihar the large increases of crops obtained by phosphate manuring wherever actual large scale trials have been made, agree with the view that there is a serious deficiency of available phosphate in these soils which greatly limits production.

Arrangements have been made for practical trials this year at several indigo factories of the efficacy of manuring with superphosphate.

Some very interesting samples of typical *bangar* and *bhat* soils were sent for investigation by Mr. C. A. Silberrad, B.A., I.C.S., Collector of Gorakhpur. The inferiority of the *bangar* soils was found to be due to the presence of a large amount of sand in it and the absence of a proper amount of lime in the form of carbonate. No harmful *usar* salts were present. *Bhat* soils contain more silt and less sand than *bangars* and are therefore more retentive of moisture.

The Chemical Adviser to the Forest Research Institute visited Pusa in September to study the methods of soil gas analysis in connection with the work undertaken by the Forest Botanist. Apparatus was lent to him in this connection.

V. Feeding Stuffs.

A Bulletin (No. 70) has been prepared summarizing the analyses of the numerous feeding stuffs received in the laboratory of the Imperial Agricultural Chemist. It is hoped that this bulletin will be useful to those maintaining cattle and horses as it gives data for the feeding values of most of the Indian feeding stuffs.

VI. Starch.

The experiments on sweet potatoes (*Ipomœa batatas*) referred to in last year's report have been continued. Five varieties were grown on manured and unmanured soils. The effect of manuring was clearly marked in all the plots and it would appear that the application of manure would pay in the cultivation of sweet potatoes.

Last year's result, that the best time of harvesting the crop is the middle of February, was confirmed this year. The analyses made show that the percentage of starch in the tubers continues to rise till about this time, after which it remains practically constant. There was, however, this year a well-defined increase in the *yield* of tubers after February, probably owing to rains which fell during the first week of February. It is possible that irrigation of the crop during the latter stages of growth would increase the output.

A point of practical importance is that if the manufacture of starch be taken up on an estate, it might be inadvisable to restrict manufacture solely to the sweet potato as the latter would be available only during a short period, namely, about two or three months. In Bihar there is another root crop which is also very suitable for the manufacture of starch and comes on to the market at a different time of year. This is the *suthni* (*Dioscorea fasciculata*) mentioned in last year's report. If both crops are utilized the manufacture of starch would be continuous from November, when the harvest of *suthni* begins, until the end of January or early February when the crop of sweet potato would become available and enable manufacture to be continued until March. In July and August a second crop of sweet potatoes would be obtained and could be utilized.

A sample of starch manufactured from sweet potato (*Ipomœa batatas*) here has been very favourably reported on by Messrs. Reckitt & Sons, Ltd., Hull, who state that at the present time such a product would sell very readily in Great Britain for industrial purposes provided that the

Food Controller would allow it to be used. Messrs. Reckitt state that it is difficult to express a precise opinion as to its selling value, but it seems probable that it would fetch about £20 per ton.

VII. Occurrence of Infertility under Trees.

It is well known that trees often give rise to infertile patches in their neighbourhood. Several causes may co-operate in this and the question has been discussed by Mr. J. N. Sen in some detail, and a collection of data has been obtained in Pusa which throw light on the question. It is shown that several trees, especially the bamboo and tamarind, bring about a concentration of soluble salts in the upper layers of the soil in their neighbourhood, probably largely owing to transpiration. An examination of *good* and *bad* soils in the neighbourhood of trees growing in different areas showed that the good soils generally contained less than 0·3 per cent. of soluble salts but that bad soils often contained more than 0·5 per cent. The nature of the soluble salts, however, greatly modifies their effect in limiting fertility.

VIII. Tobacco and Transpiration Ratio Experiments.

Pot and field experiments were started last cold weather to ascertain the effect of different manures on the yield, quality and nicotine content of tobacco plants and to ascertain the effect of aeration on these. The work is still in progress.

The experiments referred to in last year's report on the relation between transpiration by a plant and the assimilation of plant material have been continued but not yet completed.

IX. Programme of Work.

Major subjects.

1. Continuation of the investigations into the amount and nature of drainage water from fallow land and land bearing crops.

2. Continuation of the work on tobacco and starch up to the point necessary to complete the present investigation.

3. Experiments on the *bara* soils of the Punjab in connection with reclamation schemes. This work had been proposed by the late Mr. J. H. Barnes and it is hoped can be continued in collaboration with Mr. Wilsdon, Agricultural Chemist to the Punjab Government.

4. Continuation of a survey of indigo soils.

Minor subjects.

1. Checking analytical methods at present used at Pusa in agricultural analysis.

X. List of Publications.

(1) W. A. Davis . The Phosphate Depletion of the Soils of Bihar, and its Contingent Risks of Malnutrition and Endemic Disease: A Warning. *Agri. Jour. of India*, Vol. XII, Part II.

(2) W. A. Davis . The Phosphate Depletion of the Soils of Bihar: Its Effect on the Quality and Yield of Crops and the Contingent Risks of Malnutrition and Endemic Disease in Cattle and Man. *Agri. Jour. of India*, Indian Science Congress Number, 1917.

(3) J. N. Sen . . The Influence of the presence of Calcium Carbonate on the Determination of Available Phosphoric Acid in Soils by Dyer's Method. *Agri. Jour. of India*, Vol. XII, Part II.

(4) J. N. Sen . . Composition of some Indian Feeding Stuffs. *Bulletin 70, Agricultural Research Institute, Pusa.*

(5) J. N. Sen . . Some Observations on the Occurrence of Infertility under Trees. *Agri. Jour. of India*, Vol. XII, Part III.

(6) J. N. Sen . . Report on Agricultural Chemistry for Board of Scientific Advice.

REPORT OF THE IMPERIAL ECONOMIC BOTANISTS.

(A. Howard, C.I.E., and Gabrielle L. C. Howard, M.A.).

I. Introduction.

The Imperial Economic Botanist held charge of the section during the year.

The work of the staff continues to be satisfactory. During our absence from Pusa, the current work of the section was carried out by the Second Assistant, Maulvi Abdur Rahman Khan, except for two months during the monsoon of 1916 when he was on privilege leave. During this period, his place was taken by the Third Assistant, Choudhry Ram Dhan Singh. Both these assistants carried out successfully a large amount of responsible work. The Fourth Assistant, Babu Kashi Ram, has made himself very useful in connection with the experiments on the drying of vegetables.

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

II. Investigations at Pusa.

1. Wheat.

Pusa 12. The popularity of Pusa 12 continues to increase and the demand for seed is still much greater than the supply. At an early period of the last harvest, a large quantity of the seed of this variety, grown on the indigo estates in Bihar, was taken up by Mr. Burt for general distribution in the Central Circle of the United Provinces. The remainder was secured by the Director of Agriculture for use in South Bihar.

The demand for botanically pure selected seed of Pusa 12 for the purpose of re-stocking existing seed farms and for opening new centres was again very great but it was possible to deal with only a portion of the indents received.

In the previous report, the replacement of the country wheats by Pusa 12 in the United Provinces was described in detail and some reference was made to the various means employed. This work was again vigorously prosecuted during the year particularly in the Central Circle and in Oudh where large compact blocks of Pusa 12 are now to be seen at harvest time. On the seed farms of the Amethi Raj, an area of fifty-four acres yielded at the rate of 24 maunds to the acre. Now that the wheat profits have been devoted to the extension of seed farms, future progress in the United Provinces is likely to be still more rapid.

On the Chenab Colony of the Punjab, the advantage of growing Pusa 12 is beginning to be realized. At Gungapur, one of the large private estates in the Colony managed by Rai Sewak Ram Sahib, Pusa 12 is now the main crop and at harvest time this year this estate alone produced over 15,000 maunds of this variety. Comparative trials of Pusa 12 and Punjab 11 on this estate last year gave the following results :—

	m.	s.	
Pusa 12	19	32	per acre
Punjab 11	16	18	„ „

The plots in each case were 3·88 acres in area. There is one drawback, however, to the spread of this variety on the canal colonies, namely, the fact that at present the wheat crop is greatly overwatered. Pusa 12 is a deep-rooted wheat which does not like too much water. At Gungapur this year, this wheat gave over 12 maunds to the acre on the preliminary irrigation only. When the cultivators in this region practise water-saving methods, it is more than probable that the potential superiority of this wheat will become more evident.

Pusa 12 is now being systematically distributed by the Agricultural Department in South Bihar where its superiority over the local wheat has been established as the result of numerous trials. A large amount of seed was supplied this year to the Director of Agriculture from the Dholi estate.

One set-back to the spread of Pusa 12 has to be recorded, namely, the damage done by the late rains when the wheat was on the threshing floor. This was most severe in the Western Districts of the United Provinces. In Bihar and Oudh, threshing at the seed farms was fortunately completed before the rains came.

Pusa 4. Where a rapidly maturing wheat is required, Pusa 4 is in great demand. In Bundelkhand, Mr. Burt has been distributing this wheat for some years and after last harvest it came into the market for the first time in bulk. The available supply was bought up at a substantial premium by Messrs. Shaw Wallace & Co., for use in their mills at Calcutta.

In the Central India States, a beginning has been made in the trial of Pusa 4. Very good crops were obtained, particularly under irrigation, and a larger quantity of seed is being given out for sowing next October.

The quality of Pusa wheat. In connection with some milling and baking trials carried out by Mr. Humphries at Weybridge, the opportunity was taken of re-testing the original stock of Pusa 4, Pusa 6, and Pusa 12 after an interval of nine generations. No change in the milling and baking qualities could be detected. All these three wheats yielded excellent bread, the loaves from Pusa 6 being perhaps the best. This is fortunate as two very promising series of crosses on this variety have now been fixed and are ready for field trials.

Wheat-breeding. While the Pusa wheats now being grown on large areas in India are markedly superior to the country wheats in yield and quality, nevertheless they are by no means the last word in plant-breeding in this crop.

Four series of crosses are now under investigation, the two most promising of which have been derived from Pusa 6. In these, an effort has been made to combine strong rooting and standing power with rust-resistance, yield and high grain quality. Some of these wheats were tried at Gurdaspur on a field scale and very high yields were obtained. Unfortunately these trials were to some extent interfered with by exceedingly heavy rain at harvest time but sufficient work had been done before the deluge to indicate the possibilities of the new types. During the coming year, further trials of these new types have been arranged for in Central India while the work at Gurdaspur will be extended.

The effect of soil temperature on development. For some years, the cause of the dying-off of the young wheat crop soon after sowing in Bihar has been under investigation at Pusa and during the last three seasons a simple remedy has been tried with success. Experience shows that the dying-off of the young wheat crop is particularly widespread in Bihar and Oudh in years when the total monsoon rainfall is large, when the rains cease early and when the sowing rains (*hathia*) fail. In such seasons, the soil is charged with large quantities of warm water and cooling is slow on account of the mass of water involved and the practice of keeping the soil closed down to prevent too much evaporation. Such soil conditions occurred in Bihar in 1914 and again in 1915 and whenever they do, it is interesting to note that the *ryots* always sow too early and often lose their wheat entirely, particularly on the heavier lands which hold the most moisture and presumably cool down more slowly than the drier, higher-lying fields. The remedy for this trouble in such seasons in North Bihar is to postpone sowing till the end of October and to cool the soil by evaporation by allowing the furrows to remain open to the sun and air for three or four days according to the amount of moisture present. When this is done, there is much less trouble on account of a hot seed-bed and white ants do little or no damage. For two seasons, this remedy has been

adopted on the Dholi estate on the large scale, and has proved of the greatest use. Previously, this estate often lost large areas of wheat from a hot seed-bed.

2. Tobacco.

The increasing popularity of Type 28 for cigarettes in many of the tobacco-producing districts of India and Burma mentioned in the last report has become still more marked during the last twelve months. Not only for cigarette manufacture but also for general use, the cultivation of this type continues to spread. The indents for seed are increasing both in numbers and in the total weight required. From all sides favourable results are reported. The principal agent of distribution is the branch of the Peninsular Tobacco Company at Dalsing Serai in North Bihar where the seed given out to *ryots* in the present year was much greater than in 1916. Numerous indents from South Bihar, the United Provinces, Punjab, Bengal and Burma were also received. To meet the increasing demand for seed, it was necessary to postpone the plant-breeding work in this crop last year and to devote the area set aside for this investigation to the growth of seed for distribution.

3. Fibres.

Considerable progress has to be reported on the Mendelian work in connection with the varieties of Roselle (*Hibiscus Sabdariffa*). The gametic constitution of the four varieties described in the Botanical Series of the *Memoirs of the Department of Agriculture in India*, (Vol. IV, No. 2) has proved to be exceedingly complex and a very large number of unit species has now been isolated in pure culture. The unravelling of the various problems involved in this work will shortly reach a stage when it will be possible to commit the results to paper.

In the case of *patwa* (*Hibiscus cannabinus*), an improved variety of which was brought out some years ago under the designation of Type 3, further promising reports have been received from various parts of India. These reports, how-

ever, were almost invariably accompanied by requests for larger quantities of seed true to type. A large indent came from the Government of Java. Only a fraction of the seed asked for could, however, be supplied in spite of a fairly satisfactory yield last harvest. An effort is being made this year to increase the area under Type 3 so as to meet the more important indents which have had to be postponed.

4. Indigo.

The results so far obtained on the improvement of indigo in Bihar and the work in progress on this crop were summed up in the *Third Report on the Improvement of Indigo in Bihar* which was published as Bulletin No. 67. Since this appeared, some further results were described in a paper on *the economic significance of the root-development of agricultural crops* read at the Indian Science Congress at Bangalore last January.

One of the problems relating to the indigo industry, namely, the seed supply, has continued to receive attention at Pusa. The conditions found to be necessary for seed production under Bihar conditions are the following: (1) the type of plant selected must be a rapidly-growing, early-flowering, bushy form with a large proportion of the lateral roots comparatively near the surface, (2) the seed must be sown in early August on high-lying, well-drained land in good condition, (3) the surface soil must be constantly cultivated during the monsoon phase to promote abundant aeration of the roots of the young crop, (4) after the *hathia*, the crop must be deeply cultivated and till seed formation is complete, any rain crusts formed must be broken up, (5) the plants must be well spaced from the beginning so that they can branch freely and the flowers formed can be visited by bees, (6) the cultivation should be so conducted that flowering takes place between the middle of October and the end of November by which date the plants should be fully loaded with pods. Proceeding on these principles, a seed crop of over sixteen maunds to the acre was obtained last season, the highest yield so far obtained at Pusa.

The effect of improved soil aeration on the production of seed in Java indigo (which has been noticed at Pusa) is becoming evident elsewhere. At Dehra Dun, where our selected indigos are being grown for seed on drained land, the favourable effect of the drains on the growth of the plant is very marked. At Ranchi, Mr. G. Milne, I.C.S., Director of Agriculture, Bihar and Orissa, reported an interesting case where a field of seed indigo failed except where large quantities of broken bricks had been added to the soil.

A study of the botanical constitution of the Java crop yielded some interesting information particularly with regard to the root-system of the various types. All the types examined were found to possess the deep anchoring root. In addition, a general correspondence between the modes of branching of the root and of the stem was observed. In the bush types, which branch at right angles to the axis, the lateral roots are also given off at right angles to the main tap root. In the vertical types, whose branches arise at an acute angle from the stem, the lateral roots arise at an angle very similar to that of the branches.

The following types of root development have up to the present been found :—

(1) *Early bush types* in which nearly all the lateral roots are at right angles and are concentrated near the surface.

(2) *Early types with a vertical habit* in which nearly all the lateral roots are concentrated near the surface but all point downwards.

(3) *Late bushy forms* in which there is a development of lateral roots from the surface to a great distance down the main root.

(4) *Late types of vertical habit* with lateral roots pointing downwards arising at regular intervals down the long main root.

(5) *Types with hardly any side branches* but a deep tap root. These types scarcely branch at all either above or below ground.

It will be obvious that if aeration is of any importance, the type which will thrive best in the monsoon in Bihar is type 1 and that type 2 will be the next best. Even if the lower portion of the root-system in these types is asphyxiated, the upper portion would be sufficient to carry on growth. Plants belonging to types 3 and 4 would lose a large portion of their root-system and even if they could struggle on would not thrive. Plants of the fifth type would be killed out. Experience shows that this is the case. Rapidly-growing, bushy indigos with most of the root-system near the surface, have successfully withstood the monsoon, while deep-rooting types belonging to classes 3, 4 and 5 have died out.

5. Gram.

After the heavy monsoon of 1916, the land at sowing time at Pusa was much too wet for gram cultivation. As was expected, the growth was very luxuriant but the yield of seed was far below the average. It is only occasionally that the highest and driest plots at Pusa are in the right condition for testing gram varieties. This circumstance has greatly hindered the work on this crop. A large number of varieties have been isolated, some of which are very promising, but it is exceedingly difficult to carry out the final trials for yield and to eliminate the less efficient types. As this work has now been hung up for several years, it is hoped to make suitable arrangements for the trials in the United Provinces.

6. Oil-seeds.

It appears from the literature that up to the present no arrangements have been made on a practical scale to have the seed of safflower (*Carthamus tinctorius*) examined with a view to its utilization in the arts. The seed is rich in oil which at present is said to be largely used for adulterating *ghi*. As it is probable that the oil may be of use in water-proofing cloth, a consignment of about a ton has been sent to England for full tests under factory conditions. If the seeds prove of value in Great Britain, it will not be a diffi-

cult matter to work up an export trade and to make use of some of the improved types of this crop isolated at Pusa.

Considerable progress was made during the year in the preliminary classification of the various types of Indian linseed so as to furnish suitable material for the further study of this crop. It is hoped to complete this introductory work during the next *rabi* season. A large number of forms have been isolated, and as was expected, the range in root development is very great.

7. Soil-aeration.

During the year under review, a large body of evidence in support of our published views on soil-aeration has accumulated. Confirmatory results from the cultural and anatomical standpoints have been published in Great Britain by one of Professor Potter's students. In India, the dependence of quality on soil-aeration has been confirmed by Mr. Clouston's experiments on cotton, sugarcane, and ground-nuts at Chandkhuri near Raipur on the *bhata* soils of the Central Provinces. At Pusa, a study of the root-systems of the types of linseed, Roselle, *patwa*, wheat and Java indigo has shown that all the varieties which really do well on the Bihar alluvium are surface-rooted kinds, while on the other hand the forms which do not thrive are deep-rooted. The facts so far brought to light indicate the all importance of soil-aeration during the monsoon phase and also confirm our ideas on the general importance of this factor. The addition of one inch of potsherds (*thikra*) to the heavy soils of the Botanical area has led to a considerable increase in the yield of grain per acre—in the case of oats the increment was 366 lb. per acre, in wheat 269 lb. per acre.

III. The Development of the Agriculture of Baluchistan.

Thanks to the increased facilities provided by the Baluchistan Administration and the effective co-operation

of the Army, the agricultural work carried out at the Fruit Experiment Station at Quetta has been extended very considerably during the year. The district work among the cultivators has necessitated the appointment of a Travelling Instructor in Agriculture while the fodder experiments in progress with the Army have involved extra expenditure on presses and seed. The cost of the experiments on vegetable drying has been met by a grant from Army Headquarters, Simla, while the fodder trials have been financed from an advance of five thousand rupees from the Assistant Director of Supplies and Transport, Fourth (Quetta) Division. The supply of fruit boxes to the public has been made possible by means of temporary loans from the Treasury.

1. The saving of irrigation water.

The principles underlying water-saving were referred to in detail in the last Annual Report as well as the result of a trial of the new system on the fields of a *zamindar*. During the past year, the demonstration work has been extended considerably near Quetta and trials have also been carried out by the Political Agent at Pishin and by the Irrigation Officer at Khushdil Khan. In spite of the fact that the winter rains last season were less than half the average, none of the demonstration crops failed and in all cases the wheat reached maturity and good yields were obtained, in some cases over 20 maunds to the acre. The success of the new methods, when carried out under cultivators' conditions, is now assured and their general adoption is only a question of time. In connection with these trials it is satisfactory to note that the people are taking to the lever harrows for crust-breaking and are favourably impressed by the rate at which irrigated land can be dealt with by the combined use of the five tine spring-tooth cultivator and the levelling beam. For the operations connected with tilth production and water saving prior to sowing, the spring-tooth cultivator is essential and its use in areas like the Pishin Valley will multiply the available cattle power by a

factor lying between 2 and 3. The Irrigation Department is co-operating in the work of bringing the new methods to the notice of the people and in teaching them the proper use of the lever-harrow and spring-tooth cultivator.

In addition to the discovery of the best means of utilizing the preliminary irrigation, other aspects of water saving have been investigated at Quetta. The results were published in a bulletin entitled *The irrigation of alluvial soils* which was afterwards reprinted in the *Agricultural Journal of India.* In this paper, the present methods of irrigation in Baluchistan and the plains of India were considered as well as the conditions underlying any successful modification of existing practices. What is wanted is a system which fulfills the following conditions :—

(1) The amount of water used must be as small as possible and the losses in the channels must be reduced to the lowest point.

(2) The method of distribution must be simple and inexpensive and must be designed to admit of the use of labour-saving devices such as harrows and reapers.

(3) The system must admit of *surface-drainage for each field* during the rains, and it must be such as to prevent the production of alkali salts.

(4) The method must be such as to assist the process of green-manuring in those areas where this is possible.

A method of irrigation based on these principles has been worked out at Quetta which appears to be a considerable improvement on present practices. The chief points in the method are the better grading of the land to be irrigated, the use of long compartments watered from one end, the provision of surface drainage where necessary, the improvement of the field channels and the control of the water by means of the canvas dam. This paper has received a good deal of favourable notice in the press and applications for a considerable number of copies have been received.

The general applicability to the plains of India of the Quetta results on water saving was demonstrated during the past wheat season. A study of the wheat crop on the Chenab Colony and the marked contrast between the manner of ripening of the same variety, grown under canal irrigation at Lyallpur and under natural moisture elsewhere, convinced us that it would be quite safe to predict that a large proportion of the canal water is wasted in the North-West. Accordingly, a memorandum to this effect was drawn up and submitted to the Director of Agriculture of the Punjab which contained detailed directions as to the actual procedure to be followed. During the past season, the new method was tried at three centres in the Punjab—Gungapur, Haripur and Sargodha. All facilities for the experiments at Gungapur and Haripur were kindly given by Rai Sewak Ram Sahib. The Sargodha trials were carried out by Maulvi Fateh-ud-Din, Deputy Director of Agriculture. In all cases, the trials were successful and quite fair crops were ripened on the preliminary irrigation (*rawani*) only without any assistance from the winter rainfall. With one more irrigation, good crops were obtained. The details are given in Table I below from which it will be evident that after the second irrigation water ceased to be a limiting factor in growth.

TABLE I.

Results of water-saving experiments on wheat (Pusa 12) at Gungapur, Haripur and Sargodha in 1916-17.

Station	No. of irrigations including the preliminary watering	Yield per acre		Average yield per acre	
		Grain	*Bhusa*	Grain	*Bhusa*
		m. s.	m. s.	m. s.	m. s.
Gungapur . .	One	12 19½	20 10	9 34	21 17
Haripur . .	„	8 31	19 14		
Sargodha . .	„	8 12½	25 27½		

Results of water-saving experiments on wheat (Pusa 12) at Gungapur, Haripur and Sargodha in 1916-17—contd.

Station	No. of irrigations including the preliminary watering	Yield per acre		Average yield per acre	
		Grain	*Bhusa*	Grain	*Bhusa*
		m. s.	m. s.	m. s.	m. s.
Gungapur . .	Two	18 0	25 8	16 11	25 5
Haripur . .	„	15 21	23 16		
Sargodha . .	„	15 12½	26 32½		
Gungapur . .	Three	14 25	18 0	15 11	22 2
Haripur . .	„	16 8	26 4		

Similar results were obtained during the last cold weather at Mirpurkhas in Sind by Mr. T. F. Main, Deputy Director of Agriculture in Sind.

In the ordinary way, the Punjabi cultivator irrigates four times for wheat—once for the preliminary preparation and three times afterwards. So inexpert are his methods that the first watering does little more than germinate the crop and carry it through the seedling stage. At an early period of development, a second watering is necessary often followed by two more—one after the New Year and the last to complete the ripening process. When water is short, only two waterings are given after sowing. At Gungapur, a yield of over twelve maunds to the acre was obtained on the *rawani* only, a result which one of us was informed in 1916 was quite impossible. Very good wheat crops can be obtained on the Canal Colonies with two irrigations and it is possible to save one-third to half the water now used. Similar results are possible on the rest of the alluvium and to a considerable extent also on the soils of the Peninsula. Translated into money, this result runs into large figures. The annual revenue derived from Government irrigation works in India is about £5,000,000 sterling.

In addition, there are numerous private irrigation works as well as a large number in the Native States. Taking the Indian Empire as a whole, there can be no question that the water wasted every year would, if used to the best advantage, bring in a very large direct revenue to the State. This of course is only one aspect of the case. Increased production means more seed to be moved by rail, more dues at the ports and a great stimulation of trade following the increased spending power of the people. A good deal of work will be necessary before India can reap the full results of these experiments. Proposals for the further development of the work have been submitted to the Government of India.

2. The improvement of fodder production.

In the last report, a detailed account was given of the preliminary trials with baled *shaftal* (*Trifolium resupinatum*) which had been carried out by various units of the Fourth Division. During the year, these trials were considerably extended and 645 maunds of *shaftal* hay were supplied for trials to various units, the details relating to the tests being supervised by Brigadier-General Cook, R.G.A. The results of these large scale experiments were exceedingly satisfactory. The Revenue Commissioner has arranged for a hundred acres of *shaftal* to be sown near Harnai which will be dried and baled next year for the Quetta Garrison. The introduction of this fodder into the Harnai Valley is expected to provide a useful rotation crop and to increase the yield of the cereals now almost exclusively grown in this tract. In other respects, Harnai is a very suitable place for this work. Water is abundant and it is situated at the rail-head of the Loralai Fort Sandeman road. The military advantage obtained by the use of such fodders is a reduction of about thirty per cent. in the total weight of forage carried on active service.

With a wider experience of the cultivation of leguminous fodder crops under Quetta conditions, the dependence of the yield on soil-aeration has become more and more

marked. In the case of lucerne, the withholding of irrigation during the resting period markedly increases the yield the following year. The rest from surface-flooding during the winter enables the soil to regain its tilth in a remarkable way. The restoration of the tilth is shown by the level growth all over the area and the small edge effects. Plots which have been irrigated during the winter, on the other hand, always show pronounced edge effects and only grow well next to the earth bunds separating the irrigation compartments. In the case of *shaftal*, soil-aeration has been found to be exceedingly important at sowing time and the crop establishes itself far more readily on a recently cultivated surface than under a crop of maize or *juar*, the soil of which has been consolidated by several waterings. The presence of aerating agents in the soil also increases the life of the crop and the total yield of fodder and seed. A good deal of work is in progress on these matters which promises interesting results.

During the last five years, considerable quantities of green fodder, mostly *shaftal*, have been sold to the Military Dairy at Quetta. *Shaftal* is much appreciated at this Dairy on account of its value in milk production. The Manager of the Dairy, Mr. J. H. Riddick, referred to this matter in his report for 1916 as follows :—

"Mr. Albert Howard, M.A., C.I.E., Imperial Economic Botanist, has assisted the Dairy by disposing of the whole of the green fodder grown at the Fruit Experiment Station to the Dairy authorities, which resulted in a most satisfactory increase in the milk yield of the animals at the Quetta Dairy. His advice on improved irrigation methods and with regard to other agricultural improvements has been of much assistance to the management."

3. The sun-drying of vegetables.

One of the difficulties encountered in connection with the supplies needed by the Army of Mesopotamia has been the provision of vegetables for the troops. In the fresh condition, transport is difficult and expensive and involves the use of cold storage at sea and at the base. In 1916, the Bota-

nical Section of the Pusa Institute was asked by the Quarter Master General to suggest means of overcoming this difficulty. The suggestion was made that the vegetables should be dried in the sun at suitable places on the Western Frontier before despatch to Mesopotamia. We undertook to work out the details of the process at Quetta, where the air is exceedingly dry, and to assist the Army in the work in the event of the method being taken up on the large scale. After an interview with General Vaughan, Director of Supplies and Transport, at Delhi in March, this was agreed to and a grant to cover the cost of the experiments was placed at our disposal by the Army. While arrangements for the work were under discussion, Baghdad was taken and the Army occupied a fertile region from which supplies of fresh vegetables could be obtained. The operations on the large scale, which had been decided upon at Quetta, were accordingly revised. It was decided to continue the work but on a smaller scale and to dry sufficient produce for the Aden garrison for a year. A portion of the vegetables necessary were grown at Quetta by the Army, the remainder at Dhadar and Mustung by the Kalat State.

The first step in the process was the working out of a suitable method of drying vegetables in the sun. This was taken in hand early in the season in April and May. The work was practically completed by the middle of June and full details were supplied to the Army before the vegetables at Quetta and Mustung were ready. A large number of vegetables, both European and Indian, were successfully dried, the cooked product in nearly every case being almost indistinguishable from fresh.

As dried vegetables are very bulky, it was necessary to find some cheap method of storing and transporting the produce. This was accomplished by steaming and pressing into bricks, one pound in weight and of such a size that they could be packed into kerosine tins which could then be soldered. For this purpose, a suitable press had to be designed. The result of this portion of the investigation was a great success and reduced the space taken up by the

product to about one-seventh. Packed in this manner, it is possible to compress the weekly supply of vegetables necessary for a battalion on active service into twelve kerosine tins which can be transported by two mules. At the time of writing, the process is in full operation in the Quetta Cantonments where a large drying ground has been arranged by the Army.

The vegetable drying experiments have aroused a great deal of interest among the *zamindars*, a large number of whom have visited the drying ground. A detailed report of the process is now in the press and it is proposed to have this translated into Urdu for local circulation. There is every prospect that the work will lead to the foundation of a new local industry.

4. Fruit-packing.

The sale of improved fruit boxes to the public during the year exceeded all expectations. It was stated in the last report that a large supply had been procured for 1916 more than sufficient to meet any demand that was likely to arise. Early in the season, however, the sales increased so rapidly that it was difficult for the staff available to place the boxes on the market fast enough. The Indian traders bought up all the crates and punnets before the season was half over and only a few peach boxes were carried over for 1917. During the season, 4,398 boxes and 366 punnets were sold, the proceeds amounting to Rs. 5,028. Had the stock been larger, boxes to the value of at least Rs. 7,500 would have been sold. The Indian dealers have now realized the value of the two-pound punnet, suitably arranged in crates, for the transport of grapes. By means of these crates, Baluchistan grapes reach distant cities of India like Madras, Bombay and Calcutta without damage. In consequence, the demand from India has increased and is likely to increase still further. The only thing needed for stimulating the grape trade was a suitable method of packing for transport and this has now been provided. The valleys of Baluchistan are eminently suitable for the cultivation of grapes. The

crop escapes the early frosts and little irrigation water is needed as the plants are grown in deep trenches protected from the drying winds. Very rarely is the crop damaged by rain during the ripening period. As regards the market, this is provided by the teeming population of India, a large proportion of whom are vegetarians who are willing to pay good prices for this fruit.

Baluchistan labours under one disadvantage as a fruit-producing area. This is the absence of a supply of cheap wood for the fruit boxes. The wood has either to be brought by sea from Norway or else hauled across the Punjab from the valleys of the Himalayas. The cost of freight on the box boards will always militate against the use of the light non-returnable package which is only used once. A method of getting over the difficulty is to use stronger crates and to arrange for their return to Quetta so that they can be used over and over again. If a crate would last for 20 to 30 double journeys to and from Quetta, the cost of the package per trip would not be very great. It might then easily pay the more substantial merchants to put a certain amount of their capital into well made crates. A suitable returnable crate has been designed and has been on the market for the last two or three years. Its extensive adoption, however, was hampered by the rules in force on the railways relating to the weighing of consignments and to the return of empties. Through the good offices of the President of the Railway Board, these obstacles have been removed. Two suggested concessions for the fruit trade received the support of the Railway Board at the last meeting of the Railway Conference Association at Simla. These were that consignments of fruit should be grouped for purposes of charge and that returnable packages, approved by the North Western Railway, should be returned free of charge to Quetta, Gulistan or Chaman. This was agreed to by all the chief railways in India. During the present year the Agent (Sir Robert Gales) and the Traffic Manager (Mr. Boalth) visited the Fruit Experiment Station at Quetta and agreed to recommend to the other railways that the cardboard boxes as well

as the returnable crates should be returned free. These concessions are greatly appreciated by the fruit trade and are certain to help materially in the improvement of the industry.

5. The propagation of fruit trees.

When the development of the fruit industry in Baluchistan was first considered, the line of advance appeared to be in the direction of improved packing. It was argued that if the fruit at present produced could be sent to the more distant Indian markets and sold to advantage, the demand for such produce would increase and the extension of the area under fruit would follow. These anticipations have been realized and the demand for nursery stock is now very great and is likely to remain so for some years. To meet this, a considerable amount of attention has been paid during the last few years to working out the best methods of propagation under Quetta conditions.

Stocks. The first point taken up in 1911 was a study of stocks. For this purpose, all the possible stocks were collected in 1912 and planted out side by side in a special stock plot. The object of this was to compare their growth and behaviour under field conditions. To bring out any differences, a piece of land was selected which was not in a very good condition as regards tilth and fertility. Almost from the very beginning results began to accumulate. It was soon evident that the stocks used on the damp soils of Great Britain and the North of France were quite unsuitable for the hot, dry soils of Baluchistan. Stocks like the Black Damask and the Mazzard, which are so much used in Great Britain, are useless for Quetta. This at once explained why the peaches, nectarines, plums and apricots worked on the former which have been introduced in such large numbers from Europe in the past have not done well in Baluchistan even under garden conditions. Cherries budded on the Mazzard have only done well on the most favoured spots where the roots are least affected by the high temperature of the soil. On the other hand, such stocks as

the Mariana, Myrobolan, Mahaleb and the Jaune de Metz Paradise have done exceedingly well. Their behaviour shows them to be eminently suitable for Baluchistan. Among local stocks, the almond is the only one which is likely to be of much use. Having discovered the best stocks, the next point was to obtain a supply ready for immediate use. With only a few small trees of each kind available, it was impossible to raise large numbers locally. The experiment was tried of importing the stocks in bulk from Orleans. For the last three years this has been done successfully. Even the delays due to the war have resulted in remarkably few casualties as will be seen from the results of 1917 (Table II) when the delays in transport were very great.

TABLE II.

The importation of stocks from France in 1917.

Stock	No. ordered	No. established
Mariana	3,000	2,195
Myrobolan	3,000	2,784
Mahaleb	3,000	3,049
Pear	1,000	380
Jaune de Metz	1,000	411
Apricot	1,000	821
TOTAL	12,000	9,640

This works out at over 80 per cent., a result which is considerably exceeded under more normal conditions of sea transport. The cost comes to about a penny for each established plant.

Management of nurseries. Having disposed of the stock question, the next point was to determine the best method of nursery management. In addition to the water supply, the limiting factors in growth were found to be two

—soil-aeration and soil-temperature. The soil-temperature factor can be kept in check by surface flooding when the soil is kept cool by evaporation. This, however, destroys the aeration and leads to poor growth. If the water supply is kept too low, the soil warms up and the roots of the young trees are affected by temperature. A satisfactory working compromise between the various conflicting factors has been tried for the last two years. To save water and to promote soil-aeration, furrow irrigation has been adopted. To keep the ground between the rows cool, the soil is mulched in May before the hot weather begins with a deep covering of a leguminous weed known as *busunduk* (*Sophora alopecuroides*). This has been found to be successful even with seedling apricots which are exceedingly sensitive to the high temperatures of the soil in June and July.

As the results obtained in the propagation of fruit trees at Quetta are likely to be of more than local interest in India, a bulletin dealing with these matters has been prepared for publication. It might easily pay in extending fruit culture in Kumaon, Kulu and Kashmir to import suitable stocks in bulk and to bud them locally. In this way, the initial expense in establishing orchards would be greatly reduced.

IV. Programme and Publications.

Programme of work for 1917-18.

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, all papers in the press which are referred to in this report have been included :—

1. Third report on the improvement of indigo in Bihar. *Bulletin 67, Agricultural Research Institute, Pusa,* 1916.

2. The influence of the weather on the yield of wheat. *Agricultural Journal of India*, Vol. XI, 1916, p. 351.
3. The economic significance of the root-development of agricultural crops. A paper read at the Indian Science Congress, Bangalore, 1917, and published in the Special Science Congress Number of the *Agricultural Journal of India*, 1917.
4. The agricultural development of North-West India. A paper read at the Indian Science Congress, Bangalore, 1917, and published in the Special Science Congress Number of the *Agricultural Journal of India*, 1917.
5. Leguminous crops in desert agriculture. *Bulletin 6, Fruit Experiment Station, Quetta*, 1916. Reprinted in the *Agricultural Journal of India*, Vol. XII, 1917, p. 27.
6. The irrigation of alluvial soils. *Bulletin 7, Fruit Experiment Station, Quetta*, 1917. Reprinted in the *Agricultural Journal of India*, Vol. XII, 1917, p. 185.
7. The sun-drying of vegetables. *Bulletin 8, Fruit Experiment Station, Quetta*, 1917.

REPORT OF THE IMPERIAL MYCOLOGIST.

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

I. Charge and Establishment.

I held charge of the Section throughout the year, and Dr. F. J. F. Shaw, D.Sc., A.R.C.S., F.L.S., remained as Second Imperial Mycologist. Dr. Shaw was absent on a course of musketry instruction at Pachmarhi, under the Indian Defence Force Act, during April, 1917. Babu N. N. Mukerji was appointed second clerk in place of Babu N. C. Sen, from August 2nd. Mr. S. N. Mitra, Second Assistant, and Babu P. C. Kar, Fieldman, returned from service under the Military Department in Mesopotamia on November 16th and their work in the campaign against flies was well reported on by their superior officers. Dr. Shaw received the degree of D.Sc., for research in Botany, from the London University during the year and Mr. J. F. Dastur, First Assistant, that of M.Sc., with distinction, in Botany, from the Bombay University.

II. Training.

Mr. Deoki Nandan, B.A., M.R.A.C., attended the Section as a private student up to the end of September. Mr. S. C. Bose, Assistant to the Mycologist, Indian Tea Association, was given a special course in laboratory technique from April 16th to May 16th. Lala Kripa Ram, L.Ag., Assistant to the Economic Botanist, Punjab, has been undergoing a special course of training since April 18th, 1917. Mr. G. S. Cheema, M.Sc., Research Scholar of the Punjab University, was permitted by the University to commence research work on plant diseases in the Mycological Section at Pusa during the vacation. He remained from June 1st to 27th, 1917.

III. Mycological Conference.

A combined conference of Mycologists and Entomologists was held at Pusa in February. There were joint

meetings on the 5th, when the proceedings were opened by the Agricultural Adviser, and on the 9th, to discuss the Rome Phytopathological Convention of 1914; on the other days the Mycologists met separately, and the sittings terminated on the 10th. Practically all those interested in Economic Mycology in India attended and much useful work was got through. This was the first occasion on which an attempt was made to bring together all the workers in the science in this country; the response and interest taken in the proceedings were most gratifying; and it is hoped to arrange similar meetings at periodical intervals, as part of a larger scheme for sectional meetings to be discussed at the next meeting of the Board of Agriculture. A report of the proceedings is in the press.

IV. Diseases of Plants.

The investigation and the demonstration of methods of control of plant diseases formed, as usual, the major part of the work of the Section. Crop parasites were collected and identified and advice given to the officers of the Department and the general public as occasion required.

(1) Paddy diseases. The investigation of *ufra*, a disease caused by an eelworm, *Tylenchus angustus*, Butl., was continued, in collaboration with the officers of the Bengal Department of Agriculture. During the past year, it has been traced across the Meghna into the districts of Backerganj and Faridpur, extending westwards as far as the river Madhumati. The area now known to be infected is, from east to west, from the Mahari river, near the Chittagong border of Noakhali, to the Backerganj-Khulna boundary, and, from south to north, from near Noakhali town, to the Dacca-Mymensingh boundary. Extension into Mymensingh, Khulna and Sylhet is probably going on. The Collector of Dacca reported that part of the winter rice crop was so severely damaged on the eastern side of the Madhupur Jungle and near the Lakhya river that it was not worth harvesting.

Experiments carried on at Pusa have thrown light on several of the anomalies in the parasitism of the eelworm which causes *ufra*. It was previously known that the spring crop, called *boro* rice, and also the transplanted autumn and winter rice, ordinarily escape the disease under natural conditions, though they can be readily inoculated artificially. As the *boro* fields are often surrounded by severely infected fields of winter (*aman*) rice, they are certainly frequently contaminated by diseased stubble from the latter, and it was not easy to understand why they are not attacked. It has now been conclusively proved that the worm cannot migrate so as to reach the upper parts of the rice plant, where alone it can feed, in dry air, but does so readily when the humidity of the air approaches saturation point, even though there is no film of free water on the plants. It has also been found that worms preserved dry retain their vitality and are able to renew active motion after at least eight months, while those kept in moist air remain alive for about four months, and those immersed in water for only one to two months. The *boro* fields are submerged in water from the time the crop is transplanted into them in December-January, until near harvest. Worms set free into this water from previously infected stubble, will die unless they can migrate from the water within a couple of months. While the seedlings are small, no doubt some can migrate to them at or near the water level, but the injury caused to rice plants at this stage of growth is slight. As the plants get bigger, only certain parts near the top of the shoot (above the upper joints of the stem and the young ear chiefly) remain susceptible to attack, as only these parts have unthickened cell walls. But the worm is unable to reach them, owing to the low air humidity between February and April, and so the plants escape the serious damage that results from an attack on the shoot while the ears are developing. The crop is harvested in April, before the humidity rises enough to allow any worms that may still remain alive on the lower parts of the plants to migrate to the top of the shoot. It has also been found that the worm

does not reproduce if immersed in water or if kept dry, but only in moist air. There is therefore no multiplication of the parasite in the flooded fields nor amongst any that may get carried up on the growing *boro* plants. If the plants are covered with bell jars, so that the air around them is kept nearly saturated, infection can readily be obtained from artificial inoculations at any time of the year. If not covered, successful infections can only be got during the rains and early cold weather, while the natural humidity is high.

The escape of the transplanted paddy is due to the fact that it is grown on relatively high ground. The crop is harvested so that not much stubble is left, and the fields are ploughed early. It has been proved that worms set free into the soil do not remain alive long, and the new crop is not transplanted out until much after the period that has proved sufficient to free the soil from infection. If worms could reach the transplanted fields from neighbouring infected broadcasted fields, they would doubtless attack the transplanted paddy; but as a rule the flood water does not rise sufficiently to establish direct connection until relatively late in the season, and often not at all. That infection in this way does, however, sometimes occur is probable from the occasional reports that have been received of injury to the transplanted winter crop.

In certain parts of the infected area, the rice *bhils** are narrow and deeply concave. In the bottom of these, the soil remains muddy until February and, where deep-water *aman* has been grown, a second growth of small shoots and ears, arising from the long, matted stubble, can be found up to mid-February. In infected *bhils* this second growth harbours large numbers of actively feeding and multiplying worms. The ground does not dry out sufficiently to permit of ploughing until February in many cases, and the new crop has to be broadcasted very soon—in March—as the *bhil* bottoms flood early. Hence the worms have only about a month to live through before the new crop is sown and free

*Basin-like depressions which always hold water in the rains.

water collects, and about another two months before the humidity rises (in May) enough to permit of migration. Reports are common that the earliest attacks of *ufra* are seen in these low-lying patches, which is just what would be expected. It is not suggested that *ufra* always, or even frequently, arises from these low-lying patches, as it has been conclusively proved that the stubble in the paddy flats that dry out in December, as the great bulk of them do, is equally able to carry over infection to the next crop. But whereas it is relatively easy to remove the infected stubble and plough early in the latter, this cannot readily be done in the former. So long as the soil remains muddy, it is practically impossible to allow the work-cattle into it, and even if the stubble could be collected, it is too wet to burn properly in December. When the stubble can be removed and the land ploughed, it is so near sowing time that the chances of killing out the worm before the new crop appears are scanty. There appear to be only two ways of dealing with these muddy patches : to drain them so that they dry in time to permit of effective stubble destruction; or to deepen them so that they can grow *boro* paddy. The latter is only possible in the vicinity of permanent waterways or *khals*, as the *boro* crop has to be irrigated during its growth, but as these *khals* replace roads throughout much of the area, there is a general demand for new ones wherever practicable. Experiments have been started to ascertain the best way of dealing with this problem.

An attempt to induce the paddy cultivators to burn the stubble and plough early was made. Leaflets were distributed throughout the infected area and several demonstrations were arranged for, partly by the Department of Agriculture and partly by the revenue officials. In the Sadar Sub-division of Tippera, 12 previously diseased plots were treated, all of which escaped *ufra;* in Chandpur 64, of which 9 got slight attacks. There was less *ufra,* however, in this district than for several years. In Dacca the land selected was very swampy and the treatment was ineffective, probably for the reasons given in the last paragraph.

When the rice worm was first described (*Pusa Bulletin* No. 34, 1913) no other instance was known of injury to cultivated plants caused by an eelworm with the peculiar surface-feeding habits of *Tylenchus angustus*. Quite recently, however, a second case has been recorded, on currants, near Cambridge (England). It seems probable that others will be discovered, now that attention has been directed to the economic importance of this type of nematodes. An account of the present stage of the investigation is in preparation for publication.

(2) " Tokra " of tobacco and mustard. Further experiments were carried out by Dr. Shaw with the object of testing the claim that sodium nitrate was a specific against this pest. The results of the previous season's work had been partly obscured by the fact that the amount of " tokra " appearing in a plot seemed to depend as much upon the degree of infection in the soil as upon the influence of any application of sodium nitrate. During the season 1916-17, the experimental plots were so arranged, in the light of the information gained during the previous season, that this factor was eliminated. It was then found that the amount of "tokra" which came up in any particular plot depended largely upon the degree of infection in the soil and was practically uninfluenced by any application of sodium nitrate upon an agricultural scale.

The species of *Orobanche* examined were *O. cernua* Loeffl. and *O. indica* Ham. and, as in the previous season, the former proved to be restricted to *Solanaceæ* while the latter occurred principally upon *Cruciferæ* and only to a modified extent upon *Solanaceæ*. With a view to testing the parasitism of these species in greater detail than was possible within the limits of a field experiment, a series of pot cultures was carried out. Four host plants were used, namely tobacco, cabbage, mustard and turnip, and these host plants were infected with seed of *O. cernua* and *O. indica* which had been collected from " tokras " parasitic both upon the species of host plant infected and upon the other three host plants. Thus pots containing tobacco

plants were infected with seed of *O. cernua* collected from *O. cernua* upon tobacco and with seed of *O. indica* collected from *O. indica* upon mustard, from *O. indica* upon tobacco, from *O. indica* upon cabbage and from *O. indica* upon turnip. The same treatment was applied to mustard and to the other host plants. The results showed that *O. cernua* was strongly parasitic upon tobacco and did not attack the other three hosts, while *O. indica* was not parasitic upon tobacco unless the seed used had been collected from plants which were parasitic upon this host, in which case such seed was not capable of infecting mustard plants with "tokra." Seed of *O. indica* collected from plants parasitic upon either mustard, cabbage or turnip, however, would not infect tobacco but was strongly parasitic upon all of these hosts. Thus there appear to be two races or strains of *O. indica*, one parasitic upon tobacco and not infecting mustard and the other parasitic upon mustard, or the allied cabbage and turnip, and not infecting tobacco. Certain of the pot cultures received heavy applications of sodium nitrate, which, however, did not have any marked effect upon the occurrence of the tokras; the details and results of all the above experiments are now in the press.

(3) Phytophthora investigations. Mr. Dastur has continued his studies on this important genus. The Black Thread disease of Para rubber trees is fully described in the Memoirs and, as a result, the attention of other workers has been directed to the similar condition prevalent in Ceylon and Java. It seems clear that the disease is found in most parts of the East where rubber is grown, but the Java workers still hold that it is due to the same parasite that causes the well-known rubber canker, and is not a new disease. Mr. Dastur has given reasons for believing the parasite to be a distinct species, a matter of considerable economic importance since the canker fungus is common especially in the neighbourhood of infected cacao trees. He has found the Black Thread fungus to be much more restricted in its parasitism than *Phytophthora Faberi*, the canker fungus, and has quite failed to get it to attack cacao and other hosts

of the latter. The remedial measures recommended are being tested on a plantation scale in Burma. The chief are the free admission of light and air amongst the trees by judicious thinning, and the cessation of tapping during the monsoon months on all diseased trees. In South India, where the same or at least a closely allied disease is under investigation, good results have been obtained by the application of antiseptic and waterproof smears to the cut surface left after tapping. Tar and tallow; sulphur, cowdung and clay, have been used, and no doubt other more efficient mixtures will be found. It is not yet certain whether similar measures will be required in the relatively drier parts of the Burma rubber districts and, at the time of writing, Mr. Dastur is carrying out further enquiries in Burma.

A second Memoir contains an account of a biologic variety of *Phytophthora parasitica*, Dastur, found in Pusa on *Vinca*. It is a weak parasite, inoculations failing as a rule unless the atmosphere is almost saturated with moisture, but succeeding in damp air on a considerable number of garden plants. The fungus is, therefore, of more scientific than economic interest.

In a third paper, Mr. Dastur discusses the conditions influencing the distribution of *Phytophthora infestans*, the cause of the common potato blight. In India the fungus is ordinarily restricted to the Himalaya, Khasi and possibly Nilgiri Hills, but periodical outbreaks have been observed in the Gangetic plain and the valleys of Assam and Sylhet. An analysis of the conditions leading to these attacks, indicates that temperature, moisture and source of origin of the tubers are all important factors in controlling the distribution of the disease. Long exposure to temperatures above 77°F., is already known to be fatal to the fungus and such temperatures are usually found at the time of sowing the plains' crop. Furthermore, damp weather at the period of fructification of the fungus (January and February in the plains) is necessary to permit free reproduction and dissemination. And unless the tubers come from some already infected area, such as the Himalaya or Khasi Hills,

they are not liable to contamination and they will escape disease in the plains, since the plains' crop is normally free and local infection not usually to be feared. The outbreaks investigated showed that the seed used was probably infected, that it was brought from the Hills when the temperature below was under the normal for sowing time, and that the crop was exposed to rain or ground fogs as it ripened. Unless all these conditions are met, the crop may be expected to escape in the plains and in most of peninsular India.

(4) Rhizoctonia and other sclerotial diseases. A severe attack of *Rhizoctonia* on jute in the experimental plots on the Dacca Farm enabled the interesting observation to be made, in July, 1916, that plots which had received heavy fertilization were practically immune. As the experiment did not give any indication of the constituents which led to this result, a new series was laid down by Mr. Finlow, Fibre Expert to the Bengal Government, and in a recent report this officer states that the results strongly suggest that potash deficiency is the main cause of the severity of the disease on the old alluvium north of Dacca. The enquiry is being followed up in connection with the accumulating evidence that certain Indian soils are dangerously deficient in one or other of the essential constituents of plant-food, and that this deficiency may be manifested in increased susceptibility of the crop to fungus diseases. This point will be further referred to under " tikka " disease of groundnut.

From time to time reports and specimens of a serious root rot of cotton in northern and western India have been received. A local investigation in the southern Punjab, supplemented by a re-examination of the material in the Pusa collections, revealed a certain definite train of symptoms, enabling the disease to be recognized with certainty. Its cause is very obscure, several fungi being present on the roots of most specimens, but none so extensively nor so regularly as to be the probable cause. Two have been isolated for further work, a *Rhizoctonia* and a sterile, non

sclerotial form. Inoculations with the former, which is present on almost all diseased plants, but often apparently in very small quantity, were carried out at Pusa but under somewhat unsatisfactory conditions as the season was far advanced and the available plants old. They gave negative results. Further trials will be made with this and the second fungus. During the enquiry, we were again confronted with the probability that there was some condition connected with the chemical composition of the soil in which this root-rot occurred which was the predisposing factor. This condition may be a weak concentration of harmful alkali salts, but the evidence is contradictory in some aspects and further enquiry and experiment will be required.

Sclerotial diseases of sugarcane and paddy. Dr. Shaw continued his investigations on these diseases throughout the year in the laboratory at Pusa and during a tour to Sindewahi Farm, Central Provinces. The specimens originally received from the Central Provinces ultimately yielded two sclerotial fungi in culture. One of these was *Rhizoctonia destruens*, Tass. and the other has not at present been identified. This second form possesses a mycelium which is almost indistinguishable from that of *R. destruens* but its sclerotia are large, irregular, white bodies very different from those of *R. destruens;* both these fungi proved to be parasitic upon the leaves of sugarcane. At Sindewahi, however, it was obvious that the most serious parasite was the second, unidentified, sclerotial fungus. This occurred all over the farm on scattered clumps of cane and resulted in the complete death of the outer leaves. The early stages of attack appeared as red spots on the leaf sheath, the inner side of the leaf sheath being covered with a thick sugary solution containing a fungal growth. As the spot spreads the mycelium forms a thick crust on the interior of the leaf sheath and the sugary solution dries up. Finally the leaf is left as a dry and withered scale and sclerotia are produced along its edges. Cultures were obtained at Sindewahi from the mycelium on the leaf, from sclerotia on the leaf, and from sclerotia in the soil. In

every case the same organism was produced in culture and inoculations with these cultures have been successful in producing the disease upon canes at Pusa. The hyphae appear to enter the leaf through the stomata and penetrate the tissues of the leaf in all directions; microscopic work on this subject is proceeding. The disease appears to be very similar to that known in Java under the name of "Het zuur Rot."

Specimens of a different sclerotial disease of sugarcane were received from Eastern Bengal during the year and appeared to be identical with the disease which is known in Java as "Djamoer Oepas." In this case very characteristic light brown spots with a dark margin occurred on the blade of the leaf together with a fungus having a brownish mycelium and irregular brown sclerotia. Both the parasitic organism and the resulting spots on the leaf were very similar to the sclerotial fungus and the leaf spots described below upon paddy.

The fungus *Sclerotium Oryzæ* Catt. was very prevalent upon specimens of diseased paddy from the Central Provinces, and associated with *S. Oryzæ* on these specimens a second sclerotial fungus was found. This latter form possessed small brown spherical sclerotia, very regular in shape and size. The fungus was obtained in culture and its parasitism upon paddy is being investigated.

Paddy in Pusa sometimes suffers from the attack of another species of sclerotial fungus with large, brown, irregular sclerotia and hyphae of the *Rhizoctonia* type. This fungus causes very distinctive spots upon the leaf sheath; these spots when mature have a light brownish central area surrounded by a dark red brown line, the central portion consists of dried and dead leaf tissue and the darker margin probably represents the active zone of the fungus. The external symptoms resemble very strongly those of the sclerotial disease of sugarcane from Dacca, and it is possible that the causal organism in the two cases is the same, but the present fungus on paddy has several points of agreement with the species *Sclerotium irregulare*, described by

Miyake as parasitic on leaf sheaths of paddy in Japan. This fungus has been obtained in culture and successful inoculations in Pusa have succeeded in producing the typical leaf spots. Further research is in progress to determine the method of parasitism and the extent of damage resulting to crops.

Several other sclerotial diseases of minor importance were observed during the year, among which the most serious were an attack of *Rhizoctonia destruens*, Tass. upon wheat and lentil (*Lens esculenta*) in Burma, and a collar rot of lemon seedlings at Nagpur caused by an unidentified species of this genus, which is also parasitic upon chilli and *Hibiscus* in Pusa. All of these fungi have been obtained in pure culture and are being studied.

(5) Anthracnose of chilli and pulses. The serious disease of chillies in Bihar, referred to *Colletotrichum nigrum* E. and Hals. in last year's report, has been found to be due to an allied but distinct fungus *Vermicularia Capsici*, Syd. The former is a North American fungus and was found to be different from the Bihar species on comparison by the mycologists of the United States Department of Agriculture, who have, as usual, given us every assistance. Subsequently the true *Colletotrichum nigrum* was found in Burmese specimens, while a third form, *Glomerella* (*Gloeosporium*) *piperata*, S. & v. S. occurs sporadically throughout India. It appears to be better to restrict the term anthracnose to these two last-named (possibly only different forms of the same fungus) and to call the disease caused by *Vermicularia* " die-back," from its most prominent symptom, the withering back of the top shoots of the plant. Mr. Dastur has carried out a more detailed study of " die-back," which it is hoped to publish during the coming year. Meanwhile experiments in its treatment are in progress. The results anticipated from the seed selection referred to in last year's report have not materialised : disease was almost as severe in the plot grown from selected as in that from non-selected seed and it is evident that the fungus does not rely on seed-infection to

secure its perpetuation. Fortunately it seems that control by spraying will be relatively easy and a detailed series of experiments has been laid down to test spraying during the present season.

The same *Vermicularia* has been found to be one of the causes of a disease of various pulses, such as cowpea and Dolichos, and of Solanaceous plants, such as tomato and brinjal. As in chillies, it has been previously confused with the anthracnoses of these crops, but it seems to be of relatively minor importance on these hosts. It has not yet been recorded outside India, except in the Philippines.

(6) " Tikka " disease of groundnut. An outbreak of this disease on the Ranchi Farm was investigated. The soil of this farm is singular in being almost devoid of sulphur, and is also markedly deficient in phosphorus. It appears from analyses carried out in Bombay that groundnuts require relatively large quantities of the latter constituent, and as the nuts mature there would seem to be a heavy drain on the phosphates of the soil. It was observed by Mr. Dobbs, Deputy Director of Agriculture, Bihar and Orissa, that at this period the disease set in and developed with great intensity. Experiments have been arranged by Mr. Dobbs this season to test the view provisionally arrived at that "tikka" disease may be symptomatic of deficiency in available phosphates, in other words may be a deficiency disease similar to jute *Rhizoctonia* as described above.

(7) Sal tree disease. The investigation on the root rot of the sál tree was continued by Dr. Shaw during the year, efforts being principally directed towards completing the life history of the fungus in artificial culture and establishing its parasitism upon the sál by means of direct infections. With this latter object, a series of inoculations was carried out in June, 1916, at Rajabhatkhawa and in August, 1916, at Dehra Dun. The inoculations at Rajabhatkhawa were examined in December last and failed to yield conclusive results. In the case of one of the trees which had been infected with cultures of *Polyporus Shoreæ*, the disease was found to be well established, but it was obvious that this

was the result of a natural infection from two neighbouring trees which had since died. In fact it is most probable that this tree was already infected in the lower roots when the inoculations were made in June, 1916, but that the disease had not at that time spread sufficiently near the surface of the soil to be visible or produced sufficiently marked external symptoms to enable the tree to be distinguished from its apparently healthy neighbours. This case serves to call attention to a great difficulty in the work at Rajabhatkhawa, namely, the impossibility of knowing whether a particular tree is or is not infected with the disease. The final stages of the disease are easily identified, the defoliation and death of the tree being accompanied by the production of a large fructification and the presence of " partridge wood " in the whole of the external tissues of stem and root in the region of the ground level. A little earlier than this however the tree appears quite healthy, and the diseased tissues can only be found at a point about 1 foot below the ground level, or perhaps diseased tissues may only be discovered by going down to a depth of 6—8 feet. It is therefore impossible to say that a tree is free from infection until the bulk of the roots have been laid bare, after which it is hardly a fair subject for inoculation experiments. This objection does not however apply to the infections carried out in collaboration with the Forest Botanist at Dehra Dun and it is hoped that these may yield more decisive results; arrangements have been made to examine them in September, 1917.

It is worth noting here that in diseases of large trees caused by Basidiomycetous fungi, the parasitism of the causal fungus has not invariably been established by the method of direct inoculation, the constant association of the fructification of the fungus with the symptoms of the disease and the presence of the mycelium in the tissues being, in some cases, the only direct evidence of the parasitism of a particular species. From this point of view some interesting information and figures should in a few years be obtainable from the " fungus observation areas " in the

Buxa Division. Even now, after only two years' continuous observation, it appears that the fungus is spreading rapidly and that the death rate of trees on which the fungus occurs is, in some plots, high : this rate however shows considerable variation from one plot to another. It must be remembered that in a slow growing forest crop such as sál, a low yearly percentage of loss, which in the case of an annual agricultural crop would be negligible, may be very serious.

(8) Peach leaf curl. This disease has long been the cause of serious loss in the important fruit-growing districts of North-West India and until recently was not considered susceptible of treatment by spraying, the relatively unsatisfactory methods of pruning and burning diseased branches being the only remedial measures advocated. Experiments conducted in America have however shown that the spread of this parasite—*Exoascus deformans*, (Berk.) Fuckel—by air-borne infection plays a very extensive part in the spread of the disease and that spraying with Burgundy mixture just before the buds open is an effective control against this trouble. In co-operation with the Agricultural Officer, North-West Frontier Province, an extensive trial of this method was carried out in the Government Orchards at Taru during January, 1917, with results which have proved very encouraging, there being a considerable difference between the sprayed orchard and neighbouring private orchards. Trials were made both with lime-sulphur mixture and Burgundy mixture and both proved satisfactory. Owing however to the ease with which it can be prepared, the latter will be the most popular with the cultivator. Spraying is to be continued at the Government Orchards during future seasons and it is hoped to introduce the practice to fruit-growers in the district and to lessen materially the damage done by this destructive disease.

(9) Other diseases of interest. The powdery scab of potatoes caused by *Spongospora subterranea*, (Wall.) John., was received from Bombay Presidency. This is the first record of any parasitic member of the Myxomycete family

in India and the first time any potato scabbing organism—common though they are in the West—has been found in this country. A considerable amount of time was given to the identification of tea and coffee parasites sent in by the officers of the Planters' Associations concerned or personally collected in previous years. In tea, Mr. Tunstall, Mycologist to the Indian Tea Association, has taken up the study of the numerous root diseases, and amongst the material he sent in was found *Sphærostilbe repens*, B. and Br., now first recorded as a tea parasite, and *Rosellinia bothrina*, (B. and Br.) Sacc. not previously known in India but found on tea in Ceylon. In coffee it was found that the Java "spider's web" disease and the widely distributed brown eye-spot disease (*Cercospora coffeicola* B. and Cke.) both occur in India, but are apparently uncommon. The suspected parasite *Pythium gracile*, Schenk, occurred on young tobacco, and Babu L. S. Subramanium was able to get it into culture, thus allowing of an accurate examination of its parasitic tendencies. So far it has been proved to attack ginger rhizomes readily, causing the soft rot disease which was described in the *Agricultural Journal of India* (Vol. VI, 1911, p. 139), as prevalent in Rangpur and Surat. It is also parasitic on tobacco and probably other crops. It is hoped to publish an account of this work shortly. Experiments with the smut of *bajra* (*Pennisetum typhoideum*) established that this disease is not influenced by rotation of fields, thereby suggesting that it is seed-borne. Attempts at seed disinfection have, however, failed. An apparently new disease of paddy due to the attack of a species of *Cephalosporium* or *Verticillium* was received from Lyallpur. The fungus is being studied and inoculations have been tried. The damage at Lyallpur was estimated at 15 per cent. of the crop and it is possible that a new and serious parasite of paddy has been discovered.

V. Miscellaneous.

The problems connected with international legislation against plant diseases, continued to engage attention. In

order to establish the scientific basis on which legislation must rest, an examination of the factors controlling the dissemination of parasitic fungi has been completed and published. Two types of dissemination should be distinguished: continuous or short-range, and discontinuous or long-range. For the former, fungi are so well equipped that measures to check it are likely to prove abortive: for the latter, on the other hand, a great body of evidence has been got together to show that, if we exclude human agency, fungi are not in a position to make such considerable jumps as to be able to cross the seas or spread from one part of the world to another at all readily. Most of the important plant diseases that have appeared in recent years can be traced to the movement by human agency of the living plant which they attack, from one part of the world to another; they follow trade routes; and when, one after another, the more isolated parts of the world are brought into contact with western civilization and opened up to trade and exploration, each lets loose its indigenous pests and diseases to infect the countries with which commercial relations become established. It is not realized how thoroughly new countries are searched for economic plants, nor how quickly attempts are made to introduce novelties, or even varieties of already cultivated kinds, from them. It is open to question whether the benefits gained from such sources are not more than counterbalanced by the new diseases that have thus been introduced.

The book on fungi causing crop diseases in India, referred to in last year's report, has been completed and is now in the press. It deals with the general principles of plant pathology and gives a detailed account, crop by crop, of the more important diseases of cryptogamic origin found in Indian field and plantation crops.

VI. Systematic Work.

This has been largely in abeyance during the year, partly owing to the difficulty of obtaining foreign assistance under present conditions. Several collections have been identified

for officers of the Agricultural and Education Departments and for others interested in Mycology. Several pathogenic species of *Aspergillus* have been sent in from the Institute of Analyses and Vaccines at Nova Goa (Portuguese India), and the interesting discovery was made that the fungus habitually found in heart-damaged bales of jute is *Aspergillus fumigatus*, Fres., already known to occur in Indian soils and to be, in other countries, a not uncommon cause of ear and lung disease in man. The new additions to the Herbarium amounted to 450 sheets.

VII. Programme of work for 1917-18.

(1) *Research work.* New diseases of Indian crops that come to the notice of the Section will be investigated as opportunity permits, but the following diseases will receive special attention and will constitute main lines of investigation.

(*a*) " Ufra " of paddy.
(*b*) *Orobanche* of tobacco and mustard.
(*c*) " Die back " and anthracnose of chilli.
(*d*) Sclerotial disease of sugarcane and paddy.
(*e*) Root rot of sál tree.
(*f*) Wilt diseases of cotton, sesamum and gram.

Minor investigations will include the study of some fruit anthracnoses, of the soft rot of ginger and of the root rot of cotton.

It is hoped to publish a hand book of diseases of crops.

(2) *Systematic work.* This will 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 lines indicated in the prospectus. Short courses may also be given as necessary.

(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.

VIII. Publications.

(1) Butler, E. J. . Report on Mycology, 1915-16, for the Board of Scientific Advice.

(2) Dastur, J. F. . *Phytophthora* sp. on *Hevea brasiliensis*. *Mem. Dept. of Agri., India, Bot. Ser.*, Vol. VIII, No. 5.

(3) Dastur, J. F. . *Phytophthora* on *Vinca rosea*. *Mem. Dept. of Agri., India, Bot. Ser.*, Vol. VIII, No. 6.

(4) Butler, E. J. . The Dissemination of Parasitic Fungi and International Legislation. *Mem. Dept. of Agri., India, Bot. Ser.*, Vol. IX, No. 1, February, 1917.

(5) Dastur, J. F. . Conditions influencing the distribution of Potato Blight in India. *Agri. Jour. of India*, Special Science Congress Number, 1917.

(6) Shaw, F. J. F. . *Orobanche* as a parasite in Bihar. *Mem. Dept. of Agri., India, Bot. Ser.*, Vol. IX, No. 3. 1917.

Proceedings of the Mycological Conference held in February, 1917.

REPORT OF THE IMPERIAL ENTOMOLOGIST.

(T. Bainbrigge Fletcher, R.N., 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, 1917. The post of Supernumerary Entomologist remained vacant throughout the year owing to the impossibility of obtaining any suitable candidate under present conditions. Mr. Y. Ramachandra Rao, M.A., Entomological Assistant in Madras, was deputed from 16th November, 1916, to work under the Imperial Entomologist for a period of two years in the first instance, to investigate the insects which occur on *Lantana* in India and Burma. Mr. C. S. Misra, First Assistant, was on privilege leave from 1st to 16th July, 1916, and again on privilege leave combined with medical leave from 24th January, 1917, to the close of the year under review. Mr. C. C. Ghosh was on privilege leave from 12th October to 15th November, 1916, and Mr. D. Nowroji from 12th October to 16th November, 1916.

D. P. Singh, Fieldman, P. Narayanan, Artist, and T. V. V. Subramani, Typist, were lent to the Military Department for Fly Control work with the Expeditionary Forces in Mesopotamia. They left Pusa on 5th July, 1916, and returned in November.

H. H. Prasad, Sericultural Fieldman, was lent throughout the year to the Imperial Agricultural Bacteriologist to assist this officer in his investigations of Pebrine.

II. Tours.

The Imperial Entomologist was on tour in Madras from 4th to 20th December, in Bengal from 5th to 10th January, and in the Central Provinces from 20th to 29th March. Mr. G. R. Dutt was on tour in Bombay from 26th February to 18th March and was accompanied by Sardar Harchand Singh, a student under training, to study crop-pests. Mr.

M. N. De, Sericultural Assistant, toured in Madras and Bombay from 23rd December to 9th January. The Fieldmen were sent on tour as occasion required throughout the year, chiefly in connection with outbreaks of pests.

III. Training.

Two students were under training in Entomology at the commencement of the year under review. Of these, Sardar Harchand Singh, deputed by Patiala State, completed the full course, and Deoki Nandan, a private student, discontinued the course from December, 1916, on appointment to the Agricultural Department. A short course of practical training in collecting, rearing and control of insects was also given to Safdar, a Fieldman, sent by the North-West Frontier Province.

IV. Insect Pests.

Numerous observations on Insect Pests have been made during the year but these cannot be given in detail here without unduly swelling this Report. Particular attention has been paid to the pests of sugarcane and of stored grain and the more important observations are noted below :—

1. Cotton. The experiments, referred to in last year's Report, were continued and tabulation of results has been taken in hand. Breeding of parasites of cotton bollworm (*Earias* spp.) was continued and living parasites were despatched to the Punjab in July and August, 1916. Specimens of these parasites were sent to Mr. Brues, who informs us that they belong to the genus *Microbracon*, and not *Rhogas* as previously supposed.

2. Rice. The life-history of *Nephotettix bipunctatus* was worked out. A Tubificid worm was sent in from Hmawbi, Burma, as damaging rice, but does not seem to be of regular occurrence as a pest.

3. Sugarcane. Considerable attention has been paid during the year to the important subject of borers. Hitherto several different species of borers, all superficially very much alike, have been mixed together under the name

of Moth Borer (*Chilo simplex*), which was supposed to attack sugarcane, maize, *juar* (*Sorghum vulgare*) and rice. An attempt was made to find out whether there were really one or several species concerned. As a result the following species have been discriminated up to the time of writing this Report, *viz.*:—

(1) *Chilo simplex*, found in maize, *juar* and rice.

(2) *Diatræa suppressalis* (*auricilia*), found in sugarcane principally. A few only have been found in *juar* and none in maize.

(3) *Diatræa venosata* (*striatalis*), found in sugarcane and a thick variety of *juar*, and none in maize.

(4) *Diatræa* sp. There is one unidentified species found in sugarcane only. It was reported some years ago from Pabna and has recently been found at Dacca.

All the above forms had hitherto been spoken of as *Chilo simplex*. Besides these, there are:

(5) *Papua depressella*, which, as reported last year, had hitherto been known as a rootborer. But as will appear from the figures given below, it proves to be the most injurious of all the borers in the young stage of the sugarcane, its activities becoming less as the cane grows.

(6) *Scirpophaga xanthogastrella* (*auriflua*), which is one of the first borers to attack the young cane. It is active in cane throughout the year.

(7) *Sesamia inferens*, which is known to occur in maize, *juar*, sugarcane and rice and several other plants of the Order Gramineæ.

This year a careful watch has been kept on the time of occurrence of all the above borers and an attempt has been made to find out the extent of damage which they cause.

On the Pusa Farm about $4\frac{1}{4}$ acres are under thick varieties of sugarcane, *viz.*, Purple Mauritius (half-an-acre), Sathi No. 131 (a little more than two-and-three fourths

acres) and Sathi No. 15 (a little less than one acre). There are also very small plots of other thick varieties, *e.g.*, Kaludaie Budhan, Dacca Cane, D·99 and Ashy Mauritius. A little more than one acre is under 21 different varieties which are classed as thin canes but some of them, *e.g.*, Meneria, might be described as of medium thickness. Of the half acre under Purple Mauritius $\frac{1}{4}$ acre was planted in November 1916; the other half of the Purple Mauritius and all the rest were planted in February, 1917. The plot of Purple Mauritius has been specially grown for entomological observation and experiment and this cane has always been critically examined while the others have been superficially examined for comparison of results. All the time the sugarcane has been in the field there have been maize and *juar* growing somewhere in the Farm. The progress of the insects in sugarcane, maize and *juar* has been carefully watched and is briefly described below. Red Rot in sugarcane has necessarily come under observation and there has been a good opportunity of comparing the damage caused by it with that caused by insects.

In the middle of April the plants of the plot of Purple Mauritius planted in November were slightly ahead in growth of those of the plot planted in February, but the difference in growth did not indicate a difference of about four months in planting. The damage noticed about this time was almost wholly due to insects and the damage in the former plot was 6·3 per cent. while in the latter plot it was 2·3 per cent. Taking both the plots together, of the total damage:

Scirpophaga xanthogastrella was responsible for 1·7 per cent.

Diatræa suppressalis for 2·3 per cent.

Gryllotalpa africana for 0·1 per cent.

Red Rot for 0·22 per cent.

All the affected plants were cut out and destroyed with the insects. All this time *Chilo simplex* and *Sesamia inferens* were abundant in Rabi maize and in a very small extent in Rabi *juar*.

In the second week of May the plot of Purple Mauritius planted in November was damaged to the extent of 8·9 per cent.—

Papua depressella being responsible for about 5·8 per cent.

Red Rot being responsible for about 1·1 per cent.

Termites being responsible for about 0·8 per cent.

Diatræa suppressalis being responsible for about 0·66 per cent.

Scirpophaga xanthogastrella being responsible for about 0·52 per cent.

There was one shoot damaged by *Gryllotalpa africana* and two shoots damaged apparently by Red Ants. At this time there was no difference noticeable in the growth of the plants.

In the third week of May the plot of Purple Mauritius planted in February was damaged to the extent of about 11·5 per cent., the following being responsible for the damage :

Papua depressella about 8·1 per cent.

Red Rot about 2·27 per cent.

Diatræa suppressalis about 0·7 per cent

Termites about 0·41 per cent.

Scirpophaga xanthogastrella about 0·06 per cent.

There was one shoot apparently damaged by Red Ants.

All the affected plants were cut out and destroyed with the insects in both the plots.

About this time (*i.e.*, second and third weeks of May) all the other plots of sugarcane were also examined to note the extent of damage, though the affected plants were neither cut out nor critically examined to find out the agent of damage as was done with the Purple Mauritius plants. The damage was however similar in all external appearances and the agents would most probably be the same as observed in the case of the Purple Mauritius.

The damage in Sathi No. 131 was 7·5 per cent.

The damage in Sathi No. 15 was 9·6 per cent.

The damage in Meneria was 10·6 per cent.

The damage in all the other 25 varieties, mostly thin, taken together was 9 per cent.

It would appear that the damage in these plots was about the same as in the Purple Mauritius plots from which all affected plants had been cut out and destroyed with the insects in April.

Throughout May *Chilo simplex* and *Sesamia inferens* were feeding in Rabi maize and to a very small extent in Rabi *juar*.

In the latter part of June the damage in the Purple Mauritius plot was about 25 per cent., the following being responsible for it :—

Red Rot about 15·4 per cent.
Papua depressella about 6 per cent.
Diatræa suppressalis about 2·2 per cent.
Scirpophaga xanthogastrella about 1·1 per cent.
Termites about 0·2 per cent.
Sesamia inferens about 0·06 per cent.
A few *Diatræa venosata* were found at this time.

All affected plants were cut out and destroyed with the insects.

About this time the damage in Sathi No. 131 was about 10 per cent. As far as could be judged by external examination, about 3·5 per cent. was due to Red Rot and about 6·5 per cent. to insects.

Sathi No. 15 suffered to the extent of about 8 per cent., damage due to Red Rot being about 2·5 per cent., and that due to insects being about 5·5 per cent.

Damage in Meneria was about 14·3 per cent., Red Rot being responsible for about 11 per cent. and the insects for about 3·3 per cent.

The damage in the other (mostly thin) varieties taken together was about 7 per cent., Red Rot being responsible for about 3 per cent. and the insects for about 4 per cent.

About this time *Chilo simplex* was practically absent from maize and *juar*.

The points to note are the following :—

(1) The high percentage of damage by Red Rot.

(2) In the Purple Mauritius plot all affected plants had been cut out once in April and again in May. Still the amount of damage due to insects in June was greater than in any of the other plots. It is probable that Purple Mauritius is more liable to damage by insects than the other varieties. In order to test the effect of this treatment of cutting out affected shoots further experiments will be undertaken next year with a single variety. This year's experience however leads us to believe that the only insect which will be amenable to this treatment is *Scirpophaga*.

Now that the other borers can be distinguished and therefore their habits definitely studied, other methods of control will have to be found out by further study and experiment.

Other insects observed for the first time to feed under ground among sugarcane roots include—

Alissonotum piceum grubs.
Alissonotum simile grubs.
Myllocerus blandus grubs.

A Melolonthid grub (probably *Anomala* sp.) has been observed definitely to gnaw into sugarcane stems from the side, causing a dead heart in the case of young shoots or killing the shoots and young plants. The grubs are still feeding and have not yet been reared.

Myllocerus discolor grubs have been found commonly among sugarcane roots.

The search for Coleopterous larvæ among sugarcane roots has been continued and several Chrysomelid and weevil grubs have been found which are still feeding at the time of writing this report.

As reported last year, termites have been observed to cause more damage to new shoots than to setts. Further observation confirms the view that it is only in particular

soils that termites cause damage to sugarcane setts and shoots.

An experiment was undertaken in an area which is known to be very much infested by termites to find out the strength of Lead Arsenate solution which would be suitable for dipping the setts in order to protect them from termites. Lead Arsenate manufactured by the Thomsen Chemical Company was used. A strength of 1 lb. in 2 gallons of water has been found satisfactory. Even a strength of 1 lb. in 1 gallon of water can be used without any harmful effects on germination. Weaker strengths up to 1 lb. in 4 gallons water are also effective.

4. Maize. The larvæ of *Heliothis obsoleta* caused a curious form of damage by boring into the tender top portion of the stem.

5. Fruit Flies. Large numbers of Fruitflies have been reared in the quest for parasites, but with little success. At Pusa *Chætodacus cucurbitæ*, for example, appears to be almost free of parasites, although in Southern India it is attacked by *Opius fletcheri*, which has been introduced from India into Hawaii with considerable success. *Carpomyia vesuviana*, however, is parasitized extensively and further consignments of living pupæ were sent to Italy in the endeavour to introduce these parasites there. An important paper by Professor Bezzi, on the Fruitflies of the genus *Dacus* occurring in India, Burma and Ceylon, has appeared during the year, the information contained in it being largely based on material sent from Pusa. Professor Silvestri has also described several Braconid parasites of Indian Fruitflies and has published a note on the occurrence of *Dacus oleæ* in India and also a description of its parasite in North-West India.

6. Life-histories of insects. In the Insectary more than 200 different lots of insects were reared and observations made on their life-history and habits as far as possible. Of these, many were new to Science and practically none had been reared before. Several of them may be ranked among pests and may be serious occasionally, for

instance, (1) a Cerambycid borer of Sann-hemp. The beetle girdles the stem and deposits the egg inside the stem The apical portion of the stem beyond the girdle dries. The grub bores inside the plant which dies. (2) A Cerambycid borer of *Phaseolus aconitifolius*. This also similarly causes the plant to die. (3) A Dermestid beetle which infested and destroyed some stored snake skins. (4) *Anobium* sp. in stored Cumin seeds and Aniseeds. It proves to be a serious pest of these seeds in store.

Investigations into the life-history and habits of the pests and other insects were continued. The important points observed with regard to some of them are noted below :—

Pea stem fly. Three different varieties of peas were grown in the Insectary compound, some mixed with barley and others alone, for carrying on observation with regard to *Bruchus affinis*. Incidentally it was observed that those which grew alone and thinly were damaged by the stem fly while the others escaped.

Eugnamptus marginatus was kept under observation throughout the year in the Insectary as well as outside on an affected mango tree. The grubs have been observed to rest in the soil from about September to March-April. The beetles are active mostly in July and August although some may be observed before and after this period of greatest activity. Although the grubs were resting in the Insectary, one beetle was found laying eggs and cutting leaves in March, but under the climatic conditions in Bihar the grubs had no opportunity of developing as the cut leaves dried quickly; some of these eggs were collected and reared in the Insectary, but only two attained the adult stage, one in April and one in May, and the others were resting at the time of writing the report.

Heliocopris bucephalus. A complete cycle was obtained in the Insectary. The beetles appear in the months of June to September but mostly in July. The grubs take about a year to grow.

Attagenus piceus has been observed to take one to three years to complete its life-cycle.

Hieroglyphus banian. In the Insectary there is a cage into which a pair was introduced in 1905. Since then they hatch out regularly every year in that cage and are fed and allowed to oviposit. The broods have been observed to extend gradually. Last year (1916) they hatched in June and the last of the adults died on 15th February, 1917. Of course different batches of eggs hatched at different intervals up to August.

Some individuals of *Polytela orientalis* have been observed to rest for the whole year in the pupal stage, whilst others emerged in the first year.

Melittia eurytion, which bores and causes a swelling in the stem of *Trichosanthes dioica* and other cucurbitaceous plants in the Rains, has been observed to rest for the remainder of the year in the larval stage inside a very stiff cocoon.

Cosmopteryx manipularis, a miner in bean leaves, has been observed to rest in the larval stage from about November to July.

The Cerambycid borer occurring in *Phaseolus aconitifolius* stem in the Rains, has been observed to rest for the remainder of the year in the larval stage.

Oides bipunctatus has been observed to have only one generation in the active season in the Rains, the rest of the year, as reported before, being passed in the egg stage.

The Eurytomine Chalcidid grub in apricot seed probably rests for two years inside the seeds in some cases, although most come out as adults after one year. In the Insectary some grubs were observed to rest for about a year and a half and then die.

Agrypnus fuscipes. One grub about one-third grown was collected in November 1914. It lived and grew in the Insectary since then, being fed wholly on Scarabæid and other similar grubs. It pupated and emerged in June, 1917, after living for about $2\frac{1}{2}$ years in the Insectary. The life-cycle therefore seems to take about three to four years.

Odontotermes assmuthi. Colonies were established in artificial cages in July but all died by about October. In

the cages buried in the Insectary compound no colony lived for the whole year.

Lampyris marginella has been found, by observation outside, to have probably one generation in the year.

Ancylolomia chrysographella hibernates in the larval stage from about November to about March-April. Then it has several broods, each cycle taking about a month. It has been observed to breed mostly among wild grasses.

Aspongopus brunneus has been observed to cause serious damage to pumpkin plants. A cycle was observed of this insect.

Massepha absolutalis and another Pyralid rolling bamboo leaves have been observed to rest in the larval stage in winter and summer.

Pyrausta machæralis has been observed to hibernate in the larval stage.

Complete cycles were observed of *Pericallia ricini*, *Amsacta moorei* (form *sara*), *Hister* sp. and a Halticid beetle on *Anisomoles ovata*.

Pempheres affinis, the cotton stem weevil, has been observed to breed in a new foodplant *Triumfetta* sp. (N. O. Tiliaceæ).

Polyommatus bœticus has been observed to breed in the flowers of *Butea frondosa* (Palas) in such large numbers as to be reckoned as a pest of these flowers.

7. Grain storage experiments. The storage experiments were continued and the results so far obtained are briefly noted under different heads.

(*i*) *Wheat.* Many of the results which promised success on the first year's trial on a small scale were upset when tried on a medium storage scale this year. But some important differences were observed in the habits of the two principal pests we have to deal with at Pusa, *i.e.*, *Calandra oryzæ* and *Rhizopertha dominica*. *Rhizopertha* cannot breed when there is free access of air, but under the reverse conditions (*e.g.*, in earthen vessels with their mouths plastered up with mud) it is capable of doing much more damage and that in a much shorter time than *Calandra oryzæ*

Air and light retard *Calandra oryzæ* and if one can take the trouble of exposing the grain to air and light at frequent intervals very little damage is done. But this is not practicable when large quantities have to be stored.

In the light of this experience wheat has been stored this year under a method of outdoor storage in granaries made entirely of straw. In this condition the grain will remain exposed to the natural changes of climate and is not expected to be susceptible to attack by *Rhizopertha*. It remains to be seen whether *Calandra oryzæ* also is retarded. If successful, this method will be applicable to storage in bulk as well as in small quantities. At the same time arrangements have been made to give a satisfactory trial to the method of storage under sand.

(*ii*) *Rice*. The lime treatment of husked rice has been continued and it is giving the satisfactory result reported last year.

(*iii*) *Pulses*. Pulse seeds have to be protected in store against *Bruchus chinensis* which has been observed to breed in the larger varieties of peas (*Pisum sativum*), *arhar* (*Cajanus indicus*), lentil, *khesari* (*Lathyrus sativus*), *mung* (*Phaseolus radiatus* and *P. mungo*), *bora* (*Vigna catjang*), *bakla* (*Vicia faba*) and gram, and cause serious damage to them. Keeping the seeds covered with sand, coarse or fine, has given the best result, the seeds remaining in good condition and perfectly safe.

A species of *Bruchus* has been found to damage bean seeds in store in the same way as the above. The same method of storing under sand is applicable.

The small pea (*Pisum arvense*), as reported previously, is not liable to be damaged by *Bruchus chinensis* in store. But it is infested by *Bruchus affinis* in the field. This was dealt with in the last year's report. A system of sunning the harvested seeds has been tried this year and the result remains to be seen.

(*iv*) Besides the insects mentioned above, of the others which are found in stored wheat and rice, (1) *Tribolium castaneum* and (2) *Tenebroides mauritanicus* are very com-

mon, but they are always found in company with *Calandra oryzæ* and *Rhizopertha dominica.*

Tribolium has been observed to occur with *Rhizopertha* more than with *Calandra* and some experiments have been undertaken to find out its status definitely.

This year there was an opportunity of following *Tenebroides mauritanicus* throughout the year and of finding out its true status. It is found commonly with *Calandra oryzæ.* It takes about a year to complete the life-cycle, the adult beetles appearing and laying eggs in July-August and the rest of the year being passed in larval stage. The adult beetles live for several months and prey upon *Calandra oryzæ* weevils. The grubs do not attack the weevils but bore wheat and rice grains.

In the report for the year 1914-15, it was stated that *Tenebroides mauritanicus* on the whole played a beneficial part and its presence in affected wheat and rice would be beneficial. Further study has shown that the good the adult beetles do by preying upon the weevils is practically of no help. The real damage to wheat is done by the weevils from July onwards and *Tenebroides mauritanicus* is present at this time only in the larval stage and does not attain the adult stage till the next year. Also the beetles do not appear in sufficiently large numbers to be of use in checking the weevils.

8. Insecticides. Two insecticides were received for trial, (1) Orr's Wood Preservative against termites and (2) Incosopol, a preparation from cotton seed oil, manufactured by the Indian Cotton Oil Company of Navsari, Bombay Presidency, for trial against plant lice and such other insects. The trials have been undertaken.

Bagrada picta appeared in an experimental plot of mustard and spraying with Fishoil Resin soap at a strength of 1 lb. in 4 gallons of water checked it entirely, killing even the adults.

9. Lantana work. This work was taken up on instructions from Government and has for its object the collection of information regarding the occurrence within

the Indian Empire of any insects which may be utilized as efficient checks on the growth of *Lantana*. With this object Mr. Y. Ramachandra Rao, Entomological Assistant in Madras, has been placed on special deputation under the Imperial Entomologist, for a period of two years in the first instance, from 16th November, 1916. He has commenced work in Southern India and has made a study of the insects affecting *Lantana* in Madras, Mysore and Coorg. A large number of insects has been found to occur on *Lantana* but most of these appear to be either casuals, not confined to *Lantana* but usually very polyphagous in their habits, or of no importance as checks on *Lantana*. The insects found hitherto and which appear likely to be of use are (1) *Platyptilia pusillidactyla*, Wlk., (2) a Eucosmid moth, apparently a novelty, and (3) a Cecidomyiad fly; of these, *Platyptilia pusillidactyla*, which was one of the insects imported from Mexico into Hawáii to check *Lantana*, is already widely distributed in India and Burma, and of the other two insects further investigation is required regarding their actual value and distribution.

V. Bees, Lac and Silk.

1. Bees. The experiments with the Indian Bee (*Apis indica*) were continued. There is, however, nothing of particular interest to record.

2. Lac. Emergence of Lac larvæ took place at Pusa on 20th September, 1916, and 23rd June, 1917. Numerous inquiries for Brood-lac, etc., were dealt with during the year. No student attended the short courses in Lac-culture.

3. Silk. Three students completed short courses in Eri and Mulberry silk and six remained under training; of these nine men one was deputed by the Indore State and one by Travancore, one each came from Bombay, Mysore, Bengal, and the United Provinces and three came from Bihar.

Mr. Lefroy, the Imperial Silk Specialist, Mr. McNamara, the Director of Sericulture, Kashmir State, and Mr. Gopal Krishnan, of the Mysore Sericulture Depart-

ment, visited the Silk House. The members of the Industrial Commission, who visited the Silk House, were much interested in the reeling and weaving work.

Mulberry silkworm eggs were sent to the Travancore, Mysore, Banganapalle, Bhopal, Rewah, Indore, Gwalior, Poonch (Kashmir) and Jodhpur States, to the Deputy Director of Agriculture and Land Records, Coorg, to the different silk centres of the Salvation Army and to the Tiflis Sericultural Station (Caucasus). Eri eggs were supplied to one hundred applicants and mulberry eggs to ninety-one applicants. Eri and Mulberry seed cocoons were sent to the Director, Entomological Section, Cairo (Egypt). Mulberry cuttings and seeds were supplied to the Director of Agriculture, Burma, and to the Agricultural Officer, North-West Frontier Province, respectively. Castor and Mulberry seeds, Mulberry cuttings and samples of different kinds of silk were distributed to many inquirers. Instructions for rearing, reeling, dyeing, bleaching and spinning were given by correspondence. Univoltine Mulberry silkworm eggs were sent to Shillong, Muktesar and Guindy (Madras) for cold storage and gave satisfactory results on rearing in November and March.

We at last seem to have succeeded in establishing a multivoltine hybrid race, the yield of silk of which is about 75 per cent. more than the multivoltine races generally reared in Bengal. All the eggs of the last three generations of this race have hatched like the eggs of multivoltine races and it is hoped that they will continue to do so in future. The time has perhaps come to introduce the race in the various rearing centres.

About 19 different varieties of Mulberry trees have been planted and consignments of leaves, flowers and fruits of some of them have been sent for identification to the Economic Botanist of the Botanical Survey of India, Calcutta. Silk Exhibits were sent to the Bengal Art Exhibition, Darjiling, the Mysore Dasara Exhibition, and to the Burma Exhibition held in Rangoon in connection with the Viceroy's visit. A Silver Medal was awarded from the Darjiling Exhibition and honourable mention was made

by the Mysore Dasara Exhibition Committee. Two reelers were sent to the Burma Exhibition to demonstrate the Bengal method of reeling.

Silk pieces to the value of Rs. 644 were sold and the proceeds credited to Government.

An improved Silk Twisting Machine has been made recently, on which about half-a-pound of Mulberry, Muga or Tasar reeled silk can be twisted by a boy or girl in eight hours. A twisting machine has been lent to the Deputy Director of Agriculture, Assam. Mulberry, Eri, Muga and Tasar show cases were supplied to the Director of Sericulture, Kashmir State, and to the Agricultural Inspector, Muzafferpur. Some very fine silk guts were especially made for Galvanometer magnet at the request of the Officer-in-Charge, No. 18 Party (Magnetic), Survey of India.

Various experiments to improve the Mulberry silkworm races were carried on, and the Second Report on these Experiments is now in the press. Bulletin No. 39 on Mulberry Silkworm rearing, the second edition of which has come out, has become very popular.

VI. Illustrations.

Coloured plates illustrating the life-histories of the following insects were prepared during the year, *viz*:— *Xylotrechus quadripes*, *Laspeyresia pseudonectis*, *Ancylolomia chrysographella*, *Scirpophaga xanthogastrella* (*auriflua*), *Argina cribraria* and *Amsacta moorei sara*. Line-drawings of about sixty insects, showing life-histories in more or less detail, and about one hundred drawings of other insects, were also prepared.

The issue of coloured plates and lantern slides has been continued, thirty new plates (including eleven of mosquitos) being printed and issued during the year.

VII. Miscellaneous.

Correspondence. A total of 110 parcels of specimens, mostly of crop-pests, was received during the year for identification and advice, whilst 1,010 letters were received and 1,312 issued, but all these numbers are exclusive of a

large amount of routine correspondence, which every year becomes more and more onerous and takes up 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 (including the Micro-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 work of rearranging the Coleoptera has been practically finished, and the same has been done in the case of the Orthoptera and part of Rhynchota. The identification of the collection of Diptera was undertaken by Mr. Brunetti during the year and is now in progress.

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 have been sent out to Specialists in the groups named and our thanks are due to them for the help afforded :—

(*i*) Carabidæ to Mr. H. L. Andrewes. Partly named and returned.

(*ii*) Curculionidæ to Dr. G. A. K. Marshall. Partly named and returned.

(*iii*) Anthribidæ to Dr. K. Jordan. Not yet returned.

(*iv*) Rutelidæ to Mr. G. J. Arrow. Named and returned.

(*v*) Melolonthidæ to Mr. G. J. Arrow. Partly named and returned.

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

(*vii*) Histeridæ to Mr. G. Lewis. Not yet returned.

(*viii*) Sphegidæ to Mr. Rowland E. Turner. Returned named.

(*ix*) Formicidæ to Dr. C. M. Wheeler. Returned named.

(*x*) The Apidæ named by the late Mr. G. Meade-Waldo have been returned.

(*xi*) Braconid parasites of *Earias* to Professor C. T. Brues. Not yet returned.

(*xii*) Tenthredinidæ to Mr. Rohwer. Returned named.

(*xiii*) *Dacus oleæ* and its parasite to Professor Silvestri. Named and descriptions published.

(*xiv*) Tubificid worms infesting paddy to Lieutenant-Colonel J. Stephenson. Examined and information communicated.

(*xv*) An Ichneumonid reared from cell of *Pseudagenia blanda* to Mr. C. Morley. Named and will be returned.

(*xvi*) Hispinæ and Cassidinæ to Mr. S. Maulik. Not yet named and returned.

(*xvii*) Micro-Lepidoptera to Mr. E. Meyrick, F.R.S. Named and returned.

Various collections of Indian insects have been received and named and returned as far as possible. These included collections sent by the Provincial Agricultural Departments and by numerous correspondents.

IX. Entomological Meeting.

A Second Meeting of the Entomological Staffs of Pusa and the Agricultural Departments of the Provinces and Native States was held at Pusa from 5th to 12th February, 1917, and was attended by twenty-five members and two visitors. All Indian crops and their insect pests, and the life-histories and methods of control of these latter, were gone over and discussed, and the Meeting proved very valuable to all who attended it. A full report of the Meeting has been prepared and is now in the press.

X. Programme of work for 1917-18.

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 sugarcane, rice and cotton, of fruit-trees, of stored grain, and of insects affecting *Lantana*.

Minor.

Results in various lines of work require to be written up and published as far as possible. Work and experiments in silk, lac, and bee-keeping will be continued, and new insecticides and insecticidal methods tested as occasion arises. Systematic work on Indian insects will be carried out with our own resources and the help of specialist correspondents. Advice and assistance will be given as far as possible to Provincial Departments and to all inquirers on entomological subjects.

XI. Publications.

The following publications, either written by the Pusa Staff or based on material sent from Pusa, have been issued during the year* :—

Arrow, G. J. . . The Khapra Beetle (*Trogoderma khapra*, n. sp.), an Indian Grain-pest. (*Ann. Mag. Nat. Hist.* (8), XIX, 481-482).

Arrow, G. J. . . Coleoptera Lamellicornia, Part II; Rutelinæ, Desmonycinæ and Euchirinæ. (*Fauna of British India Series.* Pages xiii + 387, 5 tabs, 77 text-figs.)

Bezzi, M. . . On the Fruitflies of the genus *Dacus* (s.l.) occurring in India, Burma and Ceylon. (*Bull. Entl. Res.*, VII, 99-121.)

Brunetti, E. . . Diptera of the Simla District. (*Rec. Ind. Mus.*, XIII, 59-101.)

Crawford, J. C. . Nine new species of Hymenoptera. (*Insec. Inscit. Menstruus*, IV, 101-107.) [*Tetrastichus pyrillæ* and *Ooencyrtus pyrillæ*, n. spp.]

Fletcher, T. Bainbrigge. Tiger Beetle Borer of Coffee. (*Planters' Chronicle*, XII, 14-16.)

*The list includes papers in the press which are due to appear before the issue of this report.

Fletcher, T. Bainbrigge. Report on Agricultural Entomology, 1915-16. (*Board of Scientific Advice Annual Report.*)

Holmgren Karin and Nils Report on a Collection of Termites from India, Translated by T. Bainbrigge Fletcher. (*Mem., Dept. of Agri., India, Ent., Series*, Vol. V, No. 3.)

Marshall, G. A. K. On new species of Indian Curculionidæ, Part III, (*Ann. Mag. Nat. Hist.* (8), XIX, 188-198.)

Marshall, G. A. K. Rhynchophora—Curculionidæ, Part I. (*Fauna of British India Series.* Pages xi+367, 108 figs.)

Marshall, G. A. K. On new weevils of the genus *Mecysmoderes* from India. (*Ann. Mag. Nat. Hist.* (8), XIX, 395-404.)

Meyrick, E. . . Exotic Microlepidoptera, Vol. I, Part 20, Vol. II, Part 1.

Misra, C. S. . . Indian Sugarcane Leaf-hopper (*Pyrilla aberrans*, Kirby). (*Mem., Dept. of Agri., India, Ent. Series*, Vol. V. No. 2.)

Silvestri, F. . . Sulle specie di Trypaneidæ del genere *Carpomyia* dannose ai frutti di *Zizyphus*. (*Boll. Lab. Zool. Portici* XI, 170-182, figs.)

Silvestri, F. . . Descrizione di alcuni Imenotteri Braconidi parassiti di Ditteri Tripaneidi nell India. (*l.c.*, 160-169, figs.)

Silvestri, F. . . Prima notizia sulla presenza della mosca delle olive e di un parassita di essa in India. (*Reale Accad. dei Lincei* (5), XXV, 424-427, figs).

Turner, R. E. . . Notes on the Wasps of the genus *Pison* and some allied genera. (*Proc. Zool. Soc.*, 1916, pp. 591-629.)

Turner, R. E. . . On a Collection of Sphecoidea sent by the Agricultural Research Institute, Pusa, Bihar. (*Mem., Dept. of Agri., India, Ent. Series*, Vol. V, No. 4.)

REPORT OF THE IMPERIAL PATHOLOGICAL ENTOMOLOGIST.

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

I. Charge and Establishment.

I was in charge of this section in addition to my own duties as Imperial Entomologist, during the whole year (1st July, 1916, to 30th June, 1917).

Messrs. Patel and Sharma, Entomological Assistants, were absent from 5th July to 5th November, 1916, on military duty, being employed on Fly Control work in Mesopotamia.

Mr. P. G. Patel was absent on privilege leave from 10th March to 5th April, 1917, and Mr. S. K. Sen from 12th October to 23rd December, 1916.

Tours. Messrs. Sharma and Sen visited Calcutta in December and April respectively, to take down specimens of Diptera to be named up by Mr. Brunetti, who has been employed during the year on the identification of the Pusa collection of this Order.

II. Work done. Disease-carrying insects.

Saprozoic Flies.

The observations, commenced three years ago by Messrs. Howlett and Patel, on the attraction exercised on flesh flies and other insects by dead animal matter in different stages of putrefaction have been continued and the observations up to date are partially summarized below.

Pycnosoma flaviceps. Flies of this species are most strongly attracted to putrefying meat or dead animals. The life-cycle from egg to egg is about 38 days. Like *Sarcophaga* this fly is capable of infecting meat by dropping its eggs through wire gauze. These flies have lately

been noticed to be strongly attracted to over-ripe cut mango fruit. A plant (probably a *Justicia*), when in flower, attracts flies of this species (and many other Diptera) in large numbers. Maggots extracted from human nostrils, from tumours, and from the foot of a cow suffering from foot-and-mouth disease were bred out as flies which are apparently *Pycnosoma flaviceps*.

A Calliphorine Muscid, probably a species of *Chrysomyia*, is always observed to follow *Pycnosoma*. It is seen attracted to putrefying meat in the same way as *Pycnosoma*. The chief points of interest of this species are :—(*i*) the form and predaceous habits of the larvæ, (*ii*) females of this species are in the habit of producing progeny of one sex only.

The larvæ of this species are hard-bodied and spiniferous, each spine being finger-shaped, the apex again split up into hook-like bristles. They are predaceous in habit especially at times of scarcity, which is not uncommon as the number of larvæ found upon a dead animal or piece of meat is generally in excess of their food-supply. Experiments conducted on the predaceous habits of these larvæ show that they prefer *Sarcophaga* and *Pycnosoma* to other larvæ, as the larvæ of both these genera are fleshy, smooth, and apparently harmless. Phorid larvæ, excepting one spiniferous species, are also liable to be attacked and, in the absence of any such larvæ, the *Chrysomyia* larvæ fight amongst themselves and devour each other.

The habit of producing progeny of only one sex is curious. Instances of producing progeny of one sex amongst insects, such as bees and Aphids, are well known but such are usually the effect of Agamogenesis, *i.e.*, a female without sexual intercourse produces progeny. Several experiments were carried out to see if Agamogenesis is common amongst these flies. Batches of bred virgin females were confined on several occasions with food, humidity, and all other necessary conditions in a fly cage to see if they could produce progeny without having any intercourse with males. Side by side both males and females were also confined in a

separate cage as controls. Only in the control cage did the flies begin to breed. No females without intercourse of males were noticed to lay viable eggs; they laid eggs but these were never seen to hatch out. Data regarding the life duration from egg to egg, the longevity of a virgin fly, as also of a fertilized mother-fly, etc., have been observed. Under the same climatic conditions in captivity one female will produce only males whilst another will produce females, which seems to show that climatic conditions do not take any part in the causation of sex. Perhaps age and food have something to do regarding the causation of sex in this insect. Experiments on this point would certainly repay further study.

Sarcophaga ruficollis. Members of the genus *Sarcophaga* are known carrion haunters. They extrude living larvæ instead of eggs and are amongst the first visitors to exposed meat or dead animals. These flies are common about human fæces, undigested cattle dung, and carrion. They feed both upon sugary and nitrogenous substances. They breed readily in flesh and human fæces. The larval period as noticed is 10 days but the pupa takes double the larval duration. Maggots which were extracted from a tumour of a patient in Pusa Hospital proved to belong to a species of *Sarcophaga.*

Lucilia sp. A species of *Lucilia,* having a white face, dark antennæ and dark prothoracic stigmata, was seen attracted to exposed meat and dead animals at almost all seasons excepting during very severely cold days of winter. The life-history from egg to egg occupies 25 days. One fly was noticed to breed twice in her lifetime. The adults were kept alive for a period of six to seven weeks.

Lucilia sp. No. 2. This species differs from the above in having golden yellow antennæ. Freshly emerged female flies when kept in a fly cage with males and all necessaries of life refused to breed. Larvæ pupate by instalments.

Piophila casei (Sepsidæ). These little flies visit meat especially when the fatty tissues get advanced in fermenta-

tion. They breed in such material. The life-cycle period is about 11 days. The larvæ are capable of jumping, and this is a characteristic trait in them. They are parasitized by a small Hymenopterous parasite. This parasite is not confined to this species but will attack any flesh fly pupæ, preferably those of Phorids.

Aphiochæta ferruginea (Phoridæ). Flies of this species are attracted both to fresh and fermenting meat. They suck fresh meat and oviposit in the rotten meat. The mature larvæ, contrary to the habit of young larvæ, leave the place of feeding and go to an open place to pupate. The larva matures within ten days but the pupa takes the unusually long period of about four weeks.

Another species of Phoridæ, probably of the genus *Ecitomyia*, frequents decomposing meat or dead animal. Females of this species have much reduced wings. The males are darker and have well-developed wings. The larvæ are spiniferous, compressed dorso-ventrally, with a pair of conspicuous slightly protruded reddish hind spiracles, head tapering with reddish yellow tinge on the cephalic region. The pupal period was noted to be 15 days. The larva pupates where it has fed.

A large species of Phorid of the genus *Phora* was seen attracted very often to putrefying meat. Several flies caught while in the act of oviposition were noticed to be infested with an acarine mite. The infection was confined only to the abdominal segments. The larvæ are spiniferous, the thoracic segments with irregular reddish spots; they take from seven to eight days to become full grown.

Flies of a species of *Ophyra* (Anthomyiadæ) were very often noticed specially when the tin containing meat was exposed under shady places. These flies are conspicuous by their dull metallic colour. They frequent such places more for food than for oviposition. On one occasion maggots of these flies were found and reared in a vessel containing very old meat mixed with loose earth. They do not seem to breed in fresh or putrefying meat.

A species of *Drosophila* was bred out from very old flesh which had lost all smell of decomposition. The life-cycle was found to be nine days from egg to adult. The pupæ remained firmly fixed at the place of their breeding.

Besides the flies mentioned above, several species of Coleoptera are commonly attracted to putrefying flesh.

Necrobia rufipes (Cleridæ), a small metallic dark green beetle, not infrequently visits dead carcases and old meat. They have been found to exhibit a preference for eating dead maggots and animal matter. They breed freely in old meat. The larvæ are soft, elongated and slightly dilated posteriorly; the head portion is a little narrower, flat, and brownish. They were observed to eat dead or damaged flesh fly pupæ in confinement.

Four species of Histeridæ were found to be readily attracted to putrefying meat. The adult insects were observed to prey upon flesh fly maggots of any species but preferably of big species. None of these beetles have as yet been found breeding in fermenting meat or dead animal matter.

Dermestes vulpinus (Dermestidæ) visits decomposing meat or dead animals, perhaps with the object of breeding. A single beetle was seen laying a dozen eggs. The larvæ are elongated with leathery plates on the dorsum of the body which is clothed with long hairs. A single larva moults more than five times. The adult beetles counterfeit death on being alarmed. The larvæ feed upon animal matter but were not found to prey upon any living flesh fly maggots.

Adult flies of *Musca nebulo*, *M. angustifrons*, *M. nigrithoraæ*, *Ulidia ænea* and of a small species of Borboridæ were trapped whilst attempting to feed on exposed meat, but none of them were ever seen to breed in such material.

Species of *Calliphorinæ* and *Sarcophaga* breeding in flesh are subject to the attack of three kinds of parasites two of which belong to the family Chalcididæ. Of these one species with reddish hind legs attacks flesh fly maggots

in their larval stage. It was observed to hibernate in the larval state inside the flesh fly pupæ during the cold of winter. The other species is conspicuous by its widely opened mouth; this species attacks flesh fly pupæ as also full-grown larvæ. The third parasite is very minute and confines its attention chiefly to the maggots of small species of flesh flies, such as Phorids, Sepsids, etc. It has also been bred out from the pupæ of *Sarcophaga* and *Pycnosoma*. Even the parasitized pupæ of *Sarcophaga* and the *Calliphorinæ* were observed to be attacked by this small parasite, which apparently acts as a hyperparasite to the true Chalcidid parasites of *Sarcophaga* and *Calliphorinæ*.

Tabanidæ.

Observations regarding the gregarious egg-laying habit of *Tabanus nemocallosus* were continued.

Tabanidæ in general are in the habit of depositing their eggs in the vicinity of water but a great deal of difference in the selection of positions has been marked amongst these flies. Small Tabanids such as *Tabanus bicallosus*, *T. virgo*, two species of *Hæmatopota*, and *Chrysops stimulans*, are in the habit of ovipositing on the leaves of aquatic plants such as *Polygonum glabrum* and *Phragmites kurka*, which grow in shallow water. The time of egg-laying differs in different species; for instance, *Chrysops stimulans* was observed on almost all occasions to oviposit between noon and 2 P.M.; *Tabanus bicallosus* will lay throughout the day but preferably between 9 and 10 A.M.; *Hæmatopota* spp. were seen to oviposit mostly during morning and evening hours but never during the strong heat of the day.

Eggs of all these small Tabanids are always arranged in a single layer and they are free from egg parasites.

Amongst the larger species, *Tabanus albimedius* does not seem to be particular about situation; it has been observed to lay eggs on any aquatic plants grown either in deep or shallow water or mud. Any small accumulation of water either casual or permanent, will attract these flies

to lay their eggs. Even a watery appearance, such as is produced by a window-pane or a cemented floor, has been noticed to mislead these flies into laying their eggs. Leaves of big trees hanging over water at a distance from 3 to 5 yards, logs of wood, etc., have also been utilized by these flies for oviposition. *Tabanus striatus* and *T. hilaris* have more or less the same habits.

The eggs of the larger species of *Tabanus* found at Pusa are always laid in a mass. These eggmasses are cemented by gluey substances by the mother fly, apparently to protect them from enemies. Eggs of one species, probably *Tabanus speciosus*, are covered up with some chalky substance by the mother fly. All these eggmasses are subject to the attack of Chalcidid parasites.

The flies of *Tabanus nemocallosus* are moderate in size and their eggs are arranged in a mass, which is apparently uncemented and without any definite shape. Eggs of other large species are arranged more or less in a definite pattern of their own.

Tabanus nemocallosus requires a special situation to lay its eggs. A plant, *Phragmites kurka*, which is conspicuously taller than its neighbours and whose top portion droops downwards over deep water is almost invariably selected by this fly. Another plant, *Lantana aculeata*, having the same posture as described above, was seen to be utilized by these flies in June, 1917. As many as 19 flies were counted engaged in oviposition and more than 200 eggmasses, old and fresh, were seen deposited on a single plant of *Phragmites kurka* in June, 1917.

Some fresh eggmasses of *Tabanus nemocallosus* were crushed and the leaves of a plant of *Phragmites kurka* were smeared with the juice to see if these flies are attracted to such smell for oviposition but no fly seemed to take notice of it. The same experiment was repeated with the leaves of *Lantana aculeata* but met with a negative result.

Under laboratory conditions the emerging larvæ exhibited the gregarious habit as usual. A very few of them

were observed to wriggle to come up to the water surface when kept in a big aquarium; the majority of them lived in separate batches of masses at the bottom and never tried to wriggle up. They were observed to live under such conditions from 16th June to 26th June, 1917, but gradually began to decompose after this. A few survived under submerged conditions till 29th June, 1917, and almost all were found dead on 2nd July, 1917. Even when the water was rendered more or less air-free by boiling, these larvæ showed considerable resistance to death from drowning. This observation may throw a little further light on the possibility of the utilization of dissolved air by aquatic larvæ.

Freshly laid eggs, when submerged in water, failed to hatch out, but they could stand submergence for 72 hours.

Fourteen flies, both males and females, emerged in July, 1917, from the lot of larvæ of *T. nemocallosus* taken during the month of December, 1916.

Freshly emerged flies of this species would not suck blood for some time (under laboratory conditions). They are capable of resisting starvation for a full period of five days if they are kept in humid surroundings. The starved flies when allowed to bite a goat readily filled themselves with blood within five minutes. They show a marked tendency to drink water in captivity. Newly emerged flies when they have once acquired a habit of sucking sugary food are always found to be very reluctant to suck blood afterwards.

T. nemocallosus in all probability has one brood in a year. Larvæ of this species collected during December, 1916, were found about as long as a full-grown one. It is our common experience that Tabanidæ disappear during winter. No fly of this species nor of any other Tabanidæ was bred during cold season. Tabanidæ in general hibernate during the winter in their larval stage. So the larvæ of *T. nemocallosus* taken during December must be the outcome of eggs deposited in September or October. Some larvæ from the above batch have still to pupate. From these data the

maximum larval period seems to be 9 to 10 months. As the rate of development amongst these larvæ is very irregular we very often come across flies of this species at most times of the year except the winter.

The eggs of *T. nemocallosus* were found attacked by a Chalcidid parasite which is conspicuously smaller than the parasites of the larger species of *Tabanus*. An apparently similar parasite was bred out from the eggs of a species of Acalyptrate fly which were collected in the vicinity of Tabanid eggs.

Culicoides sp.

Several flies of a species of *Culicoides* were bred out from the green vegetable substances (algæ) taken from near the edges of a well reservoir. The larvæ as also adults differ from *Culicoides kiefferi*. The larvæ of the Pusa *Culicoides* are in habit of remaining half buried inside the green vegetable substance. Many larvæ were seen congregated in this way at one spot for a considerable time. Occasionally they come up to the water surface and move here and there with a characteristic vibratile motion. They often rest on the edges of a vessel containing water by keeping their heads or bodies exposed. Moulting and pupation take place under water, the pupa remaining floating on the water surface. Those which are not able to float apparently do not succeed in hatching out. A full-grown larva measures a little more than 3 mm. in length and differs from the larvæ of *Culicoides kiefferi* in having a pair of very minute hairs one on each side of the prothoracic segments. The same sort of hairs were seen on meso- and meta-thoracic segments of several larvæ. The pupa measures about half the length of the full-grown larva. The last segment of the pupa terminates in two tooth-like spines which are longer than those on the rest of the pupal body. The breathing trumpets are dark in colour, especially at the apical portion. Their stalks are lighter and thin and are supplied with three very small dark protuberances. The pupa takes about 60 hours to hatch out. The freshly emerged flies have

their abdomen of a greenish colour which gradually turns darker.

Dung-Flies.

Observations were made on the flies found breeding in the dung of various animals at Pusa and the following species were bred out :—

Breeding material	Species emerged	Remarks
Cow dung . .	*Philæmatomyia insignis.*	
	Bdellolarynx sanguinolentus.	
	Lyperosia minuta.	
	Sepsid sp	
	Anthomyiadæ, 4 spp.	
	Musca corvina.	Viviparous (flies extrude larvæ instead of eggs).
	Musca sp.	
	Pyrellia sp.	Full-grown larvæ of this species are bluish green. Puparium reddish.
Calf dung . .	*Sarcophaga* sp.	
	Phorid sp.	
	M. angustifrons.	
	Fannia sp.	Flies of this were bred out during last year.
Sheep dung . .	*Musca* sp. (*domestica* type).	A 4-striped *Musca* but according to Awati it is other than *domestica* or *nebulo.*
	Ulidia ænea.	
	Borborid sp.	
Horse dung . .	*Musca nebulo.*	
	Borborid sp.	
Litter from old manure heap	*Ulidia ænea.*	The smell of the breeding material was something like vinegar.

Mosquitos.

Investigations were made in the viability of *Stegomyia* eggs obtained in a desiccated condition in rubbish in hol-

lows of trees. It was found that, to secure viability, these eggs require to be kept under moist conditions for some time previous to desiccation, to mature their contents; this condition fulfilled, they can resist desiccation for over six months, and it is evident that at Pusa *Stegomyia scutellaris* hibernates in the egg stage and so remains until the hollows in trees are filled with rain-water towards the middle of the year.

At Pusa only *Stegomyia scutellaris* and *Aedes thomsoni* have been found capable of resisting a long period of desiccation. In the following species, which also breed mainly in hollows in trees under natural conditions, the capacity to withstand desiccation is much less, *viz.*, *Stegomyia w-album*, *Ochlerotatus gubernatoris*, *Armigeres obturbans*, and *Cyathomyia brevipalpis*.

Armigeres magnus was observed for the first time this year at Pusa and its life-history was worked out. It is rather a rare mosquito for this locality and appears in the early portion of the rainy season, breeding in bamboo stumps, and on very rare occasions in the hollows of trees as well. Its bite is rather severe. It is larvivorous in the larval stage and is the third known larvivorous species available in this locality, the other two being *Culex concolor* and *Armigeres obturbans*. Though it is not so highly larvivorous as *Culex concolor*, it is almost equal in this respect to *Armigeres obturbans*. It lays its eggs in small clusters loosely stuck to each other. They are bigger than *Stegomyia* eggs. The full-grown larvæ have comparatively large gills and their wriggling motion resembles very much that of *Armigeres obturbans*.

Some observations have been made on the bionomics of *Cyathomyia brevipalpis*, a sylvan species, which does not suck human blood and which has the habit of congregating in very large numbers in undisturbed, dark, dry places such as hollows in trees. Its eggs are laid in clusters and it breeds in hollows of trees as well as in stumps of cut bamboos. Its larval siphon is comparatively very large.

Cut pieces of bamboo, which are filled with water and placed out at Pusa as breeding-traps for some mosquitos, attract most of the mosquitos which breed in hollows in trees. The following species have been found breeding in these bamboos and reared, *viz.*, *Stegomyia scutellaris*, *S. w-album*, *Cyathomyia brevipalpis*, *Armigeres magnus* and *A. obturbans;* of these *S. scutellaris* is attracted in the largest numbers and, next to that, *S. w-album*, the other species being found only occasionally in such situations.

The Mosquito Campaign on the Pusa Estate was continued on the lines noted in last year's report. Considerable success was attained, the reduction of *Stegomyia* spp. during the rains being particularly marked.

Experiments on the rôle of blood in the development of the eggs of mosquitos were continued and the results published in the *Indian Journal of Medical Research.*

Eleven coloured plates, showing life-histories of mosquitos, were issued during the year.

III. Publications.

Sen, S. K. A preliminary note on the rôle of blood in ovulation in the Culicidæ (*Indian Journal of Medical Research*, April 1917).

IV. Programme of work for 1917-18.

Work will be continued on the life-histories and control of the insects and allied organisms which are concerned in the transmission of disease to man and animals in India.

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.

Establishment. Mr. Umrao Bahadur Mathur, Laboratory Assistant, was on privilege leave for twelve days from 10th to 21st April, 1917.

Tours. The following tours were made by me during the year under report :—

July, 1916. To Motipur factory in connection with indigo experiments.

September and October, 1916. To Kashmir to investigate conditions of silkworm seed selection in Kashmir and to Shillong to enquire into the condition of silkworm rearing in Shillong with special reference to incidence of pebrine.

November, 1916. To Berhampore and Ramnagger in connection with pebrine experiment and to Muzaffarpur to give evidence before the Indian Industrial Commission.

January, 1917. To Muzaffarpur, Dalsing-Serai, Pemberanda, Motipur and Peeprah to obtain information as to experimental indigo vats.

February, 1917. To Muzaffarpur to address the Bihar Planters' Association in connection with indigo manufacture and to Jallaha in the Champaran District to obtain information as to the design of indigo vats.

March, 1917. In the Champaran District in connection with the indigo factory enquiry.

April, 1917. To Muzaffarpur, Mohammadpur, and Dholi in connection with the experimental indigo factory.

May, 1917. To Muzaffarpur, Seraiah, Motipur, Dooriah, Belsund and Tabca in connection with the indigo experiments.

June, 1917. To Muktapur, Muzaffarpur, Motipur and Bara in connection with the indigo experiments.

Mr. Harihar Prasad, one of the Fieldmen attached to the Entomological Section, whose services were kindly lent to this Section by the Imperial Entomologist in connection with the pebrine disease experiment, was sent to Berhampore silk nurseries to demonstrate the improved method of examination of moths for pebrine as devised in this laboratory.

II. Training.

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

III. Soil Bacteriology.

Soil fertility in its relation to bacterial activities. This included further work upon nitrification with special reference to the interference with this process resulting from—

(1) The absence of the necessary specific organisms in some soils.

(2) The inhibiting action of toxins produced in soils under semi-anaerobic conditions.

The apparently complete absence of nitrifying organisms in certain soils was certified and confirmed by continued examination of further samples in which nitrification of added organic matter was secured only after inoculation with nitrifying organisms derived from other soils. The principal feature of such soils probably responsible for the absence of nitrifying organisms, is the bad texture making good tilth difficult to obtain; added to this is a deficiency of lime. Both these objectionable features

would have to be modified by cultivation, growth of green manures, and addition of lime, before inoculation of the soils could be attended with success. Defective nitrification was found especially marked in certain soils from Ranchi.

Soil I did not form any nitrate at all either with ammonium sulphate or cake, even on addition of lime. Inoculation with Pusa soil produced nitrification of 75 per cent. of ammonium sulphate and 90 per cent. of cake nitrogen in six weeks' time.

Soil II. This soil failed to produce any nitrate from ammonium sulphate in six weeks, but nitrified 50 per cent. of added cake nitrogen in this time, probably owing to the introduction of nitrifiers with the cake. Inoculation with Pusa soil resulted in complete nitrification of the ammonium sulphate in six weeks and of the cake in four weeks. In this soil addition of lime increased the rate of nitrification.

Soil III. This soil nitrified 25 per cent. of added ammonium sulphate nitrogen in four weeks; inoculation produced complete nitrification (100 per cent.) in the same time.

Soil IV. 15 per cent. ammonium sulphate was nitrified in six weeks; inoculation produced complete nitrification in the same period.

The addition of lime alone produced increased nitrification in the soils II, III and IV, but had no effect on soil I, nor was the addition of lime only in any case as efficacious as inoculation.

Barley and maize germinated and grew well in these soils for one week, after which growth stopped, the seedlings lost colour and all died after three weeks.

The effect of toxins produced by bacterial action upon nitrification was further studied. It was found that soil plus organic matter incubated under semi-anaerobic conditions gave a water extract which considerably lowered the rate of nitrification when added to another soil. This extract, on being made alkaline with caustic soda, gave a white precipitate, containing more than 5 per cent.

nitrogen; this substance has a decided retarding effect upon nitrification. Acidification of the filtrate from the above yielded a white crystalline substance soluble in dilute acids and containing rather more than 4 per cent. of nitrogen; this substance was found to increase the rate of nitrification in Omelianski solution.

Phosphate requirements of soil bacteria and their relation to plant growth. A series of experiments dealing with this subject was initiated; the results so far obtained do not suggest that solubilization of tricalcic soil phosphates by bacterial action is sufficient in amount to produce a surplus supply of soluble phosphate for the direct use of higher plants, but rather that the bacteria dissolve only sufficient for their own requirements. It seems clear, however, that such important fertilizing bacterial actions as nitrification depend for their occurrence in any useful degree upon proper supplies of phosphatic bacterial food, and it is also clear that carbonic acid resulting from bacterial action in the soil will in course of time solubilize sensible quantities of mineral phosphate.

Biological analysis of soils. Numerous samples of soil were analysed by the method elaborated in this laboratory; much useful information has been obtained in this way as to the close relation between bacterial activity and soil fertility. Application of the method to *reh* soils in the Punjab was found of great value by the Agricultural Chemist to the Government of the Punjab, whose assistant had been trained in its use in this laboratory. It is to be hoped that the untimely death of Mr. Barnes, whose criticism and advice in connection with the chemical methods involved were of great value to me, will not prevent a continuation of this enquiry.

Familiarization with the use of the method forms a useful preliminary training for students in this Section.

Green-manuring. Field experiments on the modified method of green-manuring devised in this laboratory, have been continued in collaboration with the Imperial Agriculturist on the farm, and also in the bacteriological area,

where a very large crop of Java indigo was obtained by its use; this crop was not only heavier than those obtained on control plots manured with cake, but on analysis by the Indigo Research Chemist was found to contain a higher percentage of indican.

Leguminous root nodule organisms. Experimental work upon cross inoculation with different strains of *Ps. radicicola* was carried out by Mr. Joshi, First Assistant in this Section. It was found that in several instances very substantial increase in growth both of roots and of the whole plant resulted from inoculation, although characterized by complete absence of nodule formation. This was especially the case when cultures from one species of plant were used to inoculate a different species; it is suggested that this forms a case of incompletely developed symbiotic relationship due either to greater resistance to invasion on the part of the host plant, to less parasitic ability on the part of the invading organism, or merely to a lower degree either of stimulation by the parasite or of reaction to stimulus by the plant. The results of this enquiry will be published shortly.

Plant diseases. Bacterial diseases of wheat, poppy, and citrus trees were under investigation during the year. A Memoir on the first of these is now in the press.

Poppy. Blackening and slimy decay of the stem and leaves of the opium poppy and other varieties was found to be due to bacterial rot; a description of the disease and of the causative organism is in hand for publication.

Citrus canker. This disease has been known in India for several years; some forms of it were found to be due to the action of *Ps. Citri* well known as the cause of this disease in Africa and America where it has caused very widespread and serious damage. Further investigation will be made during the next year.

IV. Indigo.

Work on this subject has been continued in collaboration with the Indigo Research Chemist and has afforded

further confirmation of the importance of bacterial action in indigo manufacture.

It has been shown that the failure in factory practice to obtain nearer approximation to the theoretic yield of indigo from the plant is due to several factors of which the following have now been found to be of importance :—

(1) *Destruction of indican in the leaf during fermentation or steeping.* This appears to be due to several causes all preventing the desirable change of indican by hydrolysis into indoxyl. These probably include the action of plant enzymes and bacteria other than those producing indoxyl from indican. With this source of loss may be associated

(2) *Incomplete extraction of the indican,* as although no residual indican may be found remaining in the plant after steeping, yet investigation has shown the very strong probability that its absence is due not to removal into solution in the steeping water but to actual destruction or decomposition *in situ.* This destruction appears to be due partly to enzymic and partly to bacterial activity other than that resulting in production of indoxyl.

Control of the fermentation taking place in the steeping vats must therefore take the form of introducing conditions which will minimize such losses, probably on the following lines :—

(1) Promote rapid extraction and so remove the indican from deleterious surroundings in the leaf tissue.

(2) Promote rapid hydrolysis and so lessen the period of time during which the indican in solution is liable to conversion into products other than indoxyl.

Extraction. Until the hot water extraction previously suggested as the most satisfactory method has been shown to be practicable on a factory scale, it seems necessary to

rely upon the production of acidity by bacterial action in the steeping vat or possibly in the *khazana*, mineral acids being too high in price at present for economic use. It has been found by the Indigo Research Chemist that extraction and acidity bear a close proportional relationship, and endeavour will be made either to isolate bacteria capable of combining acid production with indican hydrolyzing powers, or to use different species for these two purposes either concurrently or in succession.

Hydrolysis. Numerous species of indican hydrolyzing bacteria were isolated by means of indican agar; these were tested for hydrolyzing power and arranged in a relative order taking into account not only this physiological function, but also the opposite destructive action which many of them possessed. There can be no doubt that the very large differences between yields of various factories are due mainly to differences in the composition of the bacterial flora in the steeping vats; how far this may be due to bacteria carried by the plant or to those existing in the *khazana* water is not at present known, but examination of a large number of samples of the latter has demonstrated a very close connection between the actual yield of the factory and the number of hydrolyzing bacteria present in the water supply. Actual cases of increased yield as a consequence of inoculation of the vats of one factory with the steeped liquor from another of higher yield substantiate this view.

In order to make use of the inoculation method it will be necessary not only to obtain efficient species of bacteria but to ascertain the conditions under which it will be possible to introduce them into the steeping vat in sufficient numbers and in a sufficiently high state of activity to influence the style of fermentation therein. This will probably be difficult in view, firstly, of the very large volume of water involved (some seven or eight thousand gallons in each vat, and as many as six to twelve vats in use at one time) and, secondly, of the large number of other bacteria necessarily present already on the plant and in the water. As before pointed out it may be found necessary to remove the possibly deleterious influence of these latter, by use of

hot water extraction, but the economics of this method would have to be worked out before recommending its adoption as a factory procedure.

It became clear very early in this enquiry that no advance could be made in the absence of an experimental factory. Designs were accordingly made and sanction obtained for the necessary expenditure; it is unfortunate that owing to various and numerous sources of delay it has not been found possible to complete the erection and equipment of the factory in time for manufacture of Java plant at the time when it was ready for cutting; it is hoped that even with overmature plant some results of value may be obtained. The factory consists of one range of six vats with six corresponding separate *khazanas* and blowing vats. Four vats are of 100 cubic feet capacity and two of 50 cubic feet. Blowing was preferred to beating on account of the mechanical difficulties of the latter in several small vats, and of the greater possibility of controlling the oxidation and ensuring comparable conditions in all the vats.

Apart from the actual indigo produced the Indigo Research Chemist has kindly undertaken to arrange for complete analytical control of the whole series of operations in each experiment which will naturally afford more insight into the causes underlying differences in the results obtained by variations in the method of manufacture than could be secured merely by weighment of the indigo produced.

The lines of enquiry which will be adopted will aim at determining :—

(1) The possibility of increasing the yield of indigo by introducing specific bacteria into the steeping vats.

(2) The best way of doing this on a factory scale and under factory conditions.

There are indications that the second part of this enquiry will form the major problem and may require a considerable amount of time and labour to bring to a successful issue. It is also evident that should hot water extraction prove economically feasible the difficulties

connected with its solution would be greatly reduced in number.

V. Pebrine.

Further work on this subject was carried out and a Bulletin describing a revised method of examination of moths was published.

The rearing of worms (mulberry) was continued under controlled conditions with a view to determining the following points in connection with the incidence of pebrine.

Some 90 lots were reared under controlled conditions besides many larger broods in a separate *kutcha* house.

Hereditary infection. Broods were reared throughout the year to check the value of the improved method of seed selection and to compare it with the one which has been unsuccessfully used in Bengal during the past ten years. The results of the experiments confirmed the previous conclusion that many cases of pebrine in the moth may escape detection by the ordinary method, which would not do so if examined by the revised one.

Further confirmation was also obtained of the conclusion that a considerable percentage of pebrinized seed may produce worms which can be successfully carried through to the cocoon stage if afforded sufficient space and suitable food, whereas comparatively unfavourable conditions of life such as are frequently found in rearing houses as a consequence of ignorance or carelessness, would have ensured their failure to spin. Such worms, however, cannot be used for seed production, the resistance to the disease consequent upon the favourable conditions of life seldom being sufficient to do more than prevent the rapid multiplication and spread of the parasite in the body of its host which characterizes the disease in less suitable surroundings.

One of the inherent difficulties of this work is the unavoidable length of time required for the experiments; this is due to the impossibility of ascertaining either the success of an artificial infection, or even whether the vitality of the pebrine parasite has been affected by treatment, until

an obviously diseased condition has been produced in the worms as a result of the use of such infective material. This may require several weeks' incubation during which the difficulty of ensuring the absence of other sources of infection and the possibility of adventitious disease in the controls, add uncertainties to the results and make numerous duplicates necessary.

Infection through contagion or ingestion of the parasite. The necessity of work upon this second source of the disease will be realized when it is pointed out that perfectly healthy seed if reared in infected surroundings will give rise to worms which may die whilst still in the larval stage, before spinning; it is the loss of time and the money thrown away upon feeding such worms for several weeks that has caused many thousands of silkworm rearers to forsake this avocation in favour of some less precarious mode of earning a livelihood. Numerous experiments under controlled conditions have confirmed my previously expressed conclusion that the principal, if not the only, means of infection other than by hereditary transmission is by ingestion of the spore form of the parasite with the food. In this country at any rate, there seems to be no need at present to assume that any other method is of serious consequence; the prime importance of avoiding this one alone, and the great inherent difficulties of doing so, will sufficiently engage the attention of rearers for some years to come.

Experiment here has not only shown the infective nature of the pebrine spore, in India as in Europe, but has demonstrated its presence in great numbers in the dust of rearing houses and what is still more important in that of seed selection buildings. Most of these loose spores are thrown out of the gut of the infected but still feeding worm, along with the fæces, and being present in the latter in enormous numbers remain to some extent upon the leaves upon which the diseased and healthy worms alike are feeding. This naturally results in their passing with the food into the gut of the hitherto uninfected worms to act as sources of disease. Thus hereditary infection of a small percentage

of worms becomes a source of disease for a much greater number and for this reason alone would require suppression.

Infection once introduced into a rearing house is carried on and spread through the agency of dust, human beings, and insects, carrying the spores of the disease, not only from one part to another part of the same house, but almost certainly to other houses in the same neighbourhood. Similarly the spores may be spread through widely separated areas to a lesser distance by wind, but to unlimited ones by infected material such as cocoons and seed eggs sent by post, the latter material, although hereditarily free from disease, possibly contaminated during examination. My own observations in seed selection nurseries, lead me to conclude that this is by no means an unlikely means of spread of infection, aggravated in most instances by the faulty technique of examination which results in the accumulation of infective material in the selection buildings.

The persistence of infection in a rearing house will depend upon several factors about which at present very little is known, but as to which further information must be obtained if any success is to attend the efforts of rearers to avoid losses by diminishing the sources of infection. Nothing is known in India as to the action of the various antiseptics, such as copper sulphate, at present occasionally used for the disinfection of rearing houses. It has been assumed that they are efficacious, but so far as I have been able to ascertain this assumption is based, like the examination of moths, upon another one, that what is good in Europe is good in India; there is more reason indeed for assumption in the case of antiseptics than there was for the other one connected with seed selection, but it would seem highly desirable to test the efficacy of such antiseptics as are available and reasonably cheap, by actual experiment. Owing to exigencies of other work I have been obliged to confine experiment during the past season to another, and what appeared to me to be a more important point, namely, the viability or persistence of infective power

of the pebrine spore under varying natural conditions; this point seems to require elucidation as a necessary preliminary to such enquiries as the one above referred to, and the success of antiseptic measures would largely depend upon their having been devised with due knowledge of the resistance of the resting stage or spore form of the parasite to natural antagonistic or destructive agencies such as desiccation or heat.

Progress in experiment on this subject is necessarily slow for various reasons. Firstly must be taken into account the fact that no means is at present known of determining either the vitality or the infective power of this protozoal parasite except by the success or otherwise of experimental infection of its natural host; this at best requires several weeks to show any positive result, and in any case may fail to do so from causes other than loss of infective power or vitality by the parasite, such as unduly high resistance of individual hosts, making it necessary to use large numbers of the latter to eliminate this source of error as far as possible. Numerous other disturbing factors have to be allowed for such as the possibility of accidental infection from adventitious causes either in the worms under experimental infection or in the controls. Further work on the purely protozoological side of the question is required before absolute knowledge of this part of the problem can be obtained, and this in my opinion must be carried out, and carried out in India, before it will be possible to advance in actual practice much beyond the present empirical stage of treatment.

So far I have been able to ascertain with some certainty a few important points with regard to the persistence of vitality of the infective organism, amongst which may be mentioned the interesting fact that desiccation for as much as six months did not destroy the infective power of the pebrine spore, whereas moderate moisture at the same temperature rendered it innocuous in one month. It will be obvious that more complete knowledge of this sort would be invaluable in introducing any modifications in existing practice, especially those depending upon avoiding certain

climatic conditions either by confining rearing to certain seasons or to certain districts. It might be possible to make use of this line of enquiry to elucidate what appears to me to be a problem of great importance in dealing with preventive measures, not only for this but for many other parasitic infections, especially those of cultivated crops. Many parasites, both animal and plant, go through a resting stage in their life-cycle, frequently in the spore form, as in the case of *Nosema* and of many bacteria and fungi; this resting condition usually serves the purpose of carrying the organism through a period of existence during which its surroundings are unfavourable for continued vegetative activity, either by reason of failure of food supply or of seasonal or climatic changes. Emergence from the spore condition normally takes place when conditions once more become favourable for active growth, and the time of such emergence is generally determined by the coincidence of some natural stimulus with such favourable surroundings. In the case of the pebrine spore the ordinary stimulus seems to be the combination of moisture and suitable temperature found in the gut of the silkworm, which initiates the series of internal changes in the spore, culminating, under the added influence of acid found in the gut, in the protrusion of the flagellum and the emergence of the amœbula. It seems probable that the deleterious effects of continued moisture upon the vitality of the spore may be due to prematurely induced resumption of vital activity in the latter, not indeed carried so far as germination, in the absence of other necessary stimuli, but resulting, in the absence of appropriate environment for its continuation, in either partial or total loss of vitality. Other similar cases of abortive germination are common in nature, and it would appear to be worth while to make a careful study of the possibility of artificially inducing it in such a way as to destroy various parasitic organisms, in cases where the use of antiseptics or heat is not practicable. It might, for instance, be found possible to induce premature activity in the pebrine spores infesting rearing houses, simply by moistening the walls and floor at a time of year

when they would otherwise be completely dry, and although in the case of silkworm rearing the use of possibly more certain antiseptic methods is not generally prohibited by considerations of cost, in many other instances, such as occur in connection with agricultural operations, this principle might be worked out and applied where water, either natural or artificial, is available. Irrigation, for instance, might be utilized at the proper time to ensure premature germination of parasitic soil organisms, such as bacteria and fungi in the resting spore stage, or even to induce such unseasonable multiplication of the vegetative forms as to result in their exhaustion or auto-intoxication. This principle is actually made use of in the elimination of weeds from arable soil. It seems probable that similar premature or unduly rapid stimulation of embryonic activity may be responsible for the failure of crops in the seedbed or in the field, especially where germination has perhaps been inhibited by interference with the orderly sequence of enzymic activities characteristic of embryonic metabolism, such interference being due to abnormal temperature or moisture.

In order to combine such knowledge with further information of a different kind such as the effect of climate or manurial treatment upon the nutritional value of the mulberry leaf, and the resulting action upon the resistance of the silkworm to infection, much more investigation is necessary, but in view of the undoubted fact that the production of raw silk in India depends primarily, just as it does in Europe, upon the possibility of avoiding diseases amongst the silkworms themselves, of which diseases by far the most destructive is pebrine, it seems clear that such investigation is a necessary antecedent to any successful attempt to resuscitate the silk industry in India.

It may be said, therefore, that although an important step in advance has been made in the provision of an effective adaptation of Pasteur's classical method of seed selection to Indian conditions, yet the elimination of any undue percentage of hereditary infection by this means must be

supplemented by the adoption of methods of rearing calculated to avoid subsequent infection, and such can only be carried beyond their present imperfect stage of development by making use of fuller knowledge of this subject than we at present possess. I regard more complete knowledge of the life-history of *Nosema bombycis* and the reciprocal relationships between this parasite and its host as an essential preliminary to any successful solution of the fundamental problem now confronting the promoters of the industry.

VI. Saltpetre.

The artificial nitre beds described in a previous report (*Bulletin No. 68 of the Agricultural Research Institute, Pusa*), were kept under analytical observation during the year; they still continue to yield saltpetre and as this is remarkably free from sodium chloride, this method of adding to the output of saltpetre would have the additional advantage of inviting less attention from the Salt Department than is usually thought necessary in the case of extracts from village earth.

A *nuniah* was brought in during the cold weather and worked his ordinary process successfully with surface scrapings from these beds.

VII. Programme of work for 1917-18.

Major subjects.

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

2. The reciprocal relationship between bacterial activity in soil and the mineral constituents of the latter with special reference to phosphates.

Special enquiries.

3. Indigo.
4. Pebrine.

Minor subjects.

5. Biological analysis of soils.
6. Bacterial diseases of plants.

VIII. Publications.

1. Hutchinson, C. M. The Pebrine Disease of Silkworms in India. *Bulletin No. 75 of the Agricultural Research Institute, Pusa.*
2. Hutchinson, C. M. Report on Soil Bacteriology for Board of Scientific Advice, 1915-16.
3. Hutchinson, C. M. The Importance of Bacterial Action in Indigo Manufacture.
4. Hutchinson, C. M. A Bacterial Disease of Wheat in the Punjab. *Memoirs of the Department of Agriculture in India, Bacteriological Series*, Vol. I, No. 7.

REPORT OF THE IMPERIAL COTTON SPECIALIST.

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

I. Charge and Tours.

Charge. I was in charge of the Section throughout the year.

Tours. In October I toured in Khandesh, Gujarat, Belgaum and Sholapur districts; in December, in Berar and the Central Provinces; in January, Gujarat, the Southern Mahratta Country and Khandesh; in February, Gujarat and the Southern Mahratta Country, and in March, Satara District and Gujarat.

II. Cottons in the Provinces.

Bombay Presidency.

Khandesh. Excepting for a slight admixture of Upland Georgian cotton which has persisted for many years after its cultivation was abandoned in this tract, the whole of the crop consists of a variety of forms which are botanically aggregated under the species **Gossypium neglectum** of Todaro. Commercially they come under the head of "Bengals," which prevails over the greater proportion of the whole area devoted to cotton.

The varieties comprised within this species are in order of value; *Malvensis*, in most respects equal in quality and staple to Broach but failing to maintain a dominant position here on account of its low yield and ginning percentage; *vera*, slightly inferior to the above and failing on the same points; and **roseum**, a white-flowered variety, which, although producing a cotton of practically no staple, leads the field by its productiveness, hardiness and high ginning percentage so that, at present, it returns to the cultivator

about Rs. 15 per acre more than any other variety of the mixture. After long experiment the Department decided that this was the most profitable type to grow and the farmers themselves have independently arrived at a like conclusion. A large seed farm, assisted by certified cultivators, is established at Jalgaon and great quantities of seed of this low grade type have been distributed throughout the tract. It appears probable that at no far distant future this will replace the old established mixture which, after all, had its good points and many merchants now bewail what they call the deterioration of Khandesh cotton. There are already indications of the setting in of a more insistent demand for finer cottons and it would be well for the Department to be prepared to put out a higher class cotton when the demand for it reaches this tract. Possibly the lowest grade variety will always be the most remunerative but the Department must remember that there is a risk of a great fall in price of such cotton on account of overproduction.

I am of opinion that the time will soon come when the Department can safely leave the white-flowered cotton to look after itself and meanwhile attention should be centred on the improvement of the finer varieties.

In the adjoining districts of the Deccan, especially perhaps in Sholapur where a large expansion of the cotton crop has occurred in recent years, there is the same tendency to replace the old *neglectum* mixture with a pure strain of white-flowered cotton. Trials have been initiated to test the values of the other members of the mixture. This tract abuts on the part of the Nizam's Dominions where a particularly fine cotton is grown, probably the best of the Indian cottons, the **G. indicum** of Todaro, and **Bani,** Hinganghat, etc., of the trade. It would amount to a calamity if this fine strain was vitiated with the low grade cotton from Khandesh and Berar although there are distinct indications that the contamination has commenced, as will be seen from the fact that Barsi cotton has deteriorated. Along the Godavari Valley in Hyderabad Territory this

fine variety still exists in moderate purity and it is said that the bulk of the crop is bought on the spot by millowners.

A sample of white-flowered cotton was valued in Bombay as being equal to Superfine Bengal and lower than Fine Khandesh by Rs. 38 per *candy*.*

The Southern Mahratta Country. In the lower portion of Satara and throughout Belgaum, Bijapur and Dharwar, the prevailing cotton is of the species **G. herbaceum,** known as Kumptas in the trade and, in addition, there is, in the Dharwar District, an acclimatized Upland Georgian, originally from the United States of America, known commercially as Dharwar-American. For some years past introduced Broach cotton has done well in parts of Dharwar and fetched good prices, but fresh importations of seed are required as a steady deterioration has been proved to occur in this region. In the Dharwar District again, another cotton of Upland type from Cochin-China, known as Cambodia, has been introduced. The success of this crop however varies with the characters of the seasons and for this reason it will probably never become popular.

The **Kumpta** cotton is very uniform in type throughout the whole tract. It is hardy and well suited to withstand the vicissitudes of the climate. Its chief defects are a rather low ginning percentage (25) and the rosy colour of its cotton in bulk, which detracts from its value in the eyes of the Bombay trade which prefers a quite white cotton. By selection the ginning percentage has been raised by 4 per cent., its yield has also been increased and it will possibly be still further increased by the fact that a tall, shortly branched form of the plant has been found to transmit a strain of higher production and, strange to say, this style of plant appears to be the more productive in all species of Indian cottons.

How Kumpta has increased in value by selection will be immediately seen from the following figures :—

With ordinary cultivator's Kumpta giving a return of Rs. 53 per acre, one Kumpta selected type on the Dharwar

* *1 candy* = 784 lb.

Farm gave Rs. 132, a second, Rs. 130, a third, Rs. 114, and a fourth, Rs. 110. On the Gokak Farm, with the local Kumpta at Rs. 120, one selection was valued at Rs. 135 and another at Rs. 136.

These results from Kumpta are valuable as they go to show that a great advance can be at once effected by selection and that the advance even in further selection is really continuous.

By careful analysis we have realized that the **Dharwar-American** really consists of two species, a hairy plant, the true Upland Georgian, and a smooth one, the New Orleans. We have also ascertained as the result of tests that the former possesses qualities denied to the latter, *viz.*, hardiness, greater immunity from insect attack, and better cotton accompanied by a higher production. Steps must be taken gradually to eliminate New Orleans from the fields. A sample of pure Upland Georgian was valued at Rs. 505 per *candy* while one of New Orleans at the same time was valued at Rs. 490—a difference of Rs. 15 per *candy*.

Although these American cottons were introduced into the district so many years ago, they have not yet become thoroughly acclimatized, and it is the practice of the people who cultivate these to grow always a mixture of Kumpta plants in their fields. The Dharwar-American entirely fails in some years, but Kumpta is certain to give some return even in the worst of seasons. The Dharwar-American matures most of its cotton in advance of Kumpta so that a fair part of the former is picked pure, but an enquiry is to be undertaken to find out whether the inevitable mixture is a matter of any concern, the general idea being that it is not. Anyhow as the growing of the two sorts together is done to minimize the risk of loss it will be difficult to persuade the farmers to give up the practice and, fortunately, it may not be necessary to do so.

Cambodia cotton was introduced into the district a few years ago, but it is still more uncertain than Dharwar-

American, and owing to its similarity in external characters to that variety it is very difficult to detect admixture in the fields although this has gone on very rapidly.

Broach cotton has done well on a strip of country on the eastern side of the district where the south-west monsoon sets in early, but there is little chance of its ever extending beyond this tract.

The prices realized in the years 1913-1916 for Broach seed cotton of the special class, which ginned 34 on an average, have been 20 to 25 per cent. higher than those of the local cotton, and the lowest class of Broach cotton, with a ginning percentage of about 29·5, has fetched about Rs. 20 more than the local Kumpta.

The Manager of the cotton mill at Gokak supplied the following note on a test made with selected Kumpta of the Dharwar Farm and compared with local Kumpta of many parts of the Kumpta tract :—

" The cotton was considerably superior to any of the Kumpta cottons as supplied either direct by the ryots or which we have obtained from the near markets; it is bright, clean, long in staple and uniform and of middling strength; from it we spun 3 counts, *viz.* :— 20's, 30's, 40's. The yarn ran smoothly and demanded very little attention from the workpeople, and we would no doubt have received better results had we had sufficient cotton to make it worth our while to alter our machinery so that it should be spun into yarn under the best conditions.

" The loss in the blow room amounted to 8 per cent.

" The yarn gave the following tests :—

Counts	Actual average count	Actual average strength
		lbs.
40's	38·4	$34\frac{3}{4}$
30's	30·3	$46\frac{1}{2}$
20's	19·5	$82\frac{1}{4}$

"Against this we give you the result of 20's spun from Kumpta and other cotton from the places named:—

Name	Blow room loss	Average count	Strength
	per cent.		lb.
Kudchi	9½	20·4's	59½
Hubli	10	19·6's	65
Athani	11	20·6's	59½
Shedbal	10½	20·6's	59½
Jamkhindi . . .	12	19·5's	62
Mudhol	14	19·6's	69
Bagalkot . . .	14	20·1's	60
Bijapur	13½	19·6's	68
Sangli	13½	20·2's	65

"The cotton you supplied is better than the Cambodia we have seen this year and fully Rs. 20 per *candy* better than Kumptas from the surrounding districts. We send you a sample knot of 20's spun from Dharwar selected and ordinary Kumptas."

Dharwar-American has stood the test of time fairly well and, if its weaker companion, New Orleans, is cleared out, it may be a more certain crop than it is at present.

This type is grown late in parts which enjoy the advantage of two rainy seasons, and the north-east monsoon is absolutely essential to it. It is found mixed to a greater or less extent with the local Jowari Hatti or Kumpta and also less evidently so with Cambodia round Ranibennur. I have already stated that the mixture with Kumpta may not be taken as fraudulent.

As regards results from the separate tests with Upland Georgian and New Orleans during three successive seasons, the Upland type gave 50 lb. more seed cotton per acre than the ordinary field mixture, it gins 3 to 4 per cent. more and in value it commands Rs. 10 to 15 more per *candy* of lint. The New Orleans not only gives a lower percentage and poorer quality but it is behind in out-turn. It has also been

proved in the Punjab and United Provinces that the Upland Georgian is hardier and more resistant to insects and disease than the New Orleans. Of the multitude of exotic American cottons which have been tried only two of the number are worth introducing. They are far superior to the local article in quality, but they fail in yield as yet.

The area under Cambodia is gradually extending. But as has been said above, taking one season with another, Dharwar-American is more certain, and therefore the latter will continue to hold the field.

During the last six years the special class of Cambodia cotton, with a ginning percentage of 37 and over, commanded on an average Rs. 60 to Rs. 70 more per *naga* (*naga* = 1,344 lb.) than the ordinary Dharwar-American and the lowest class, with a percentage of 33·5, Rs. 30 to Rs. 35 more. Last year, however, the difference ranged from Rs. 65 to Rs. 100 per *naga*.

Gujarat and Kathiawar. Here we have the last great cotton area in Bombay. The prevailing species is *Gossypium herbaceum* of Todaro, the varieties of which are usually restricted each to a certain class of soil. On the whole the distinctions are only dimly appreciable in the external characters of the plants but they are easily detected in the lint, so that it is only when the crop is ripe that the varieties can be readily distinguished.

Starting from the southward as far north as the Tapti, we have the **Navasari strain,** which is accepted as the best cotton in India. The good soil, genial climate and proximity to the sea, all favourably influence the quality of this cotton.

Further north, about as far as the Narbada, there is the **Surti Broach strain,** which is only slightly inferior to the Navasari.

From here, however, deterioration steadily sets in. In the Broach District and adjoining parts the strain is contaminated with a high ginning, short-stapled form of uncertain ancestry called **ghogari.** Its antecedents are doubtful but it may be a cross between Wagad (to be mentioned

later) and Surti Broach. Here also in the tract called the Kahnam a variety called *kanvi* exists. It apparently cannot claim to be considered a distinct race but is probably in no way different from Surti Broach or even Navasari.

The only remaining form of *herbaceum* which reaches further north than this is the **Lalio,** which used to be distinguished by the very pendulous nature of its cotton when ripe. A great deal of the cotton which goes under this name is possibly Broach; anyhow Lalio, as we used to know it, has almost gone out of existence. On the lighter soils of North Gujarat different species of cotton appear and this mixture is in its greatest intensity in the Kaira and Ahmedabad districts. A perennial variety, *G. obtusifolium*, Todaro, the Rozi of Gujarat, is grown in fields, always as a mixture.

In Kathiawar there are the same cottons as in Gujarat, on the other hand *wagad*, a form of *herbaceum* in which valves of the bolls remain closed in the ripe bolls, is a prevalent species as is also a form of *neglectum*, called *mathio* which is said to have been introduced into Kathiawar about 1891 and gained ground after the famine year of 1899 when the local cottons were wiped out with drought.

The decreasing values of cottons as we go up from the southward undoubtedly depend on the accompanying differences of climate and soil.

Thus, if we take the value of Broach at Rs. 300 per *candy* of 784 lb. as the basis, we have—

	Rs.
Navasari	360
Surat	330
Broach	300
Kanvi or Broach in the north of Broach	285
Lalio	285
Ghogari	260
Wagad	295
Mathio	255—260
Dhollera	250

The quality of the Broach cotton is already so good that it has been difficult to effect anything tangible in its improvement, but at the Surat Farm where experiments with this end in view have been carried on uninterruptedly for many years, certain strains have been established, and these are distinctly more profitable than the local unselected cotton. Thus while ordinary Surti Broach, on the farm, gives a gross return of Rs. 89 per acre, Selection 1A gives Rs. 106, and Selection 11, Rs. 98.

Taking the average of five years, local cotton has a ginning percentage of 33·2; Selection 1A, 36·6; Selection 11, 35·2. These improved cottons are now grown on an extended scale by villagers under departmental supervision and a premium of 5 per cent. over local rates is paid by traders for the produce, but there are indications to show that this is considerably below their intrinsic value.

In the Broach District the local cotton is being mixed with an inferior type called *ghogari* as it brings in more money at present to the cultivator. From the results of the Broach plot for three years *ghogari* yields on an average 15 lb. more *kapas* per acre than the *Broach Deshi*. This together with the high ginning will pay about Rs. 3 more per acre to a cultivator.

Realizing that the people are determined to have *ghogari* the Department has started a farm at Broach to see what can be done either to improve it or to develop uniform strains. Four more or less distinct types have been separated, but the test has not been in operation long enough to furnish any results of a decisive nature. The fibre is reported on in Bombay as being short and weak and the change of quality in the Broach cotton generally is not approved of. In valuations of successive years before 1908, the difference in price between Fine Broach and Fine Surat was ordinarily Rs. 10 per *candy*, but of late years the market has been paying Rs. 30 per *candy* more for Fine Surat, and this fact supports our contention that Broach cotton has deteriorated simply by reason of the steadily increasing *ghogari* mixture. In Broach as in Khandesh and Berar

it is plain that the deterioration in quality is not due to natural causes but has been brought about by the deliberate selection of the most inferior type in the prevalent mixture. *Ghogari* is spreading southwards and it is not looking very far in advance to foresee that the whole of the South Gujarat cotton country will become contaminated with it.

In the northern part of Gujarat, with the exception of *wagad* which covers large areas to the west of Ahmedabad and which is also a cotton of good type, we have a heterogeneous assemblage of varieties which are grown capriciously throughout the area. For instance, in Ahmedabad District, *lalio*, *wagad*, *mathio*, *ghogari* and *rozi* are found not in the same fields of course but scattered indiscriminately.

Central Provinces.

In the Central Provinces the mixture of cottons in the fields is exactly as described for Khandesh in the Bombay Presidency, with the addition that a sort of acclimatized Upland Georgian from Chhutia Nagpur called *Bhuri* has been introduced into wilt-infested areas on account of its resistance to the disease. *Bani* or Hinganghat which spreads in from the direction of the Hyderabad Territory has rapidly gone out of favour on account of its low yield and low ginning percentage.

As in Khandesh, the white-flowered *neglectum* or **roseum** is being distributed lavishly to the exclusion of all other varieties. That there is abundant justification for this course is proved by the following figures: *roseum* and *Saugor jari*, both white-flowered, give a gross return per acre of Rs. 57; the yellow-flowered varieties, *Berar jari*, Rs. 41; *bani* Rs. 39; *Malvensis* Rs. 33 and *vera* Rs. 31 respectively. Two Cawnpore Selections K22 and K7 give Rs. 43 and Rs. 33. *Bhuri* is worth Rs. 51 per acre.

At Sindewahi in the Chanda District, where attention is being paid to the possibility of growing better cotton under irrigation, a very promising cross between *bani* and *deshi Lahore* has been tested but in yield it still holds a minor position. *Cambodia*, under the same conditions, gives

a gross return of Rs. 202 per acre; *roseum* Rs. 122; *Sindewahi cross* Rs. 81 and *Bhuri* Rs. 31. Cambodia is a plant adapted for irrigation and it should always occupy a place in any scheme proposed for growing irrigated cottons.

For the purpose of rigidly testing the **Sindewahi Cross** throughout the *neglectum* area, it was grown at the following places. The results here given are based on valuations alone, as the crop on account of the abnormal season was not good and no dependence could be put on acreage outturns. Taking the market price of the day of Fine Broach at Rs. 100, we had in Khandesh; Dhulia at 101·2, Jalgaon at 97·3; in Berar at Akola 97·3; in the Central Provinces at Sindewahi at 95·4; in the Panch Mahals at 97·3; in Central India at Indore 76·8. The test is being repeated during the present season at the same places. On the whole we may assume that it is possible to have a short season cotton which compares very favourably with Fine Broach. The ginning percentage is 35, which is about the highest obtainable in Broach.

On the eastern side of the Central Provinces Mr. Clouston has decided to exploit the *bhata* soil, which is a sort of laterite covering large areas of country and bearing only coarse grass, *kodra* (*Paspalum scrobiculatum*) and a little rice. At Chandkhuri, under irrigation and green-manuring, this soil grows most excellent sugarcane, groundnut, *jowar* (*Sorghum vulgare*) and Alexandrian clover. The plots of **Cambodia** and **roseum** were very good indeed. The value of the former works out to Rs. 172 gross per acre and of *roseum* Rs. 77.

A great deal depends on the amount of irrigation that can be supplied, but it seems as if a new field has been discovered for the cultivation of the high class Cambodia cotton.

Central India.

In Central India, some varieties of local and other cottons were tried in Malva but, owing to the abnormal character of the season the out-turn and other figures were not taken. Samples from Dewas and Ujjain were considered

the best and Indore came last. The cottons of Malva are naturally excellent and good results are anticipated from the trials which have now been put in hand throughout the tract.

United Provinces.

From the United Provinces, seeds of **K22** were procured from Cawnpore for trial throughout the *neglectum* area. The test is being repeated and in the last season the following comparative results were recorded. Taking the price of Fine Khandesh at Rs. 100 we have it at Cawnpore at Rs. 101; in Khandesh, at Jalgaon Rs. 97 and at Dhulia Rs. 104; at Indore in Central India at Rs. 103; at Dohad in Panch Mahals at Rs. 85. The trials must of course be continued to obtain decisive results but so far we may take it as being only slightly in advance of Fine Khandesh.

Fourteen samples of Upland Georgian cotton (the so-called **Cawnpore-American**) were received, for valuation and opinion, from the United Provinces. Two samples were good for spinning 24's, 4 from 20's to 16's, 5 from 12's to 14's and 3 for 10's and there is an extreme range of value per *candy*—of Rs. 70. This clearly shows the amount of variation which may exist in one or any species of cotton and the method of selection will depend on the aim of the grower which may be assisted or frustrated by the many variations in external conditions.

Acknowledgments. I have again to thank Messrs. Tata & Sons of Bombay who have assisted me for years in estimating the values of many samples I have submitted to them. My thanks are also due to the Secretary of the Bombay Chamber of Commerce for the gift of standard trade samples of Indian cottons.

III. Programme of work for the year 1917-18.

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.