SCIENTIFIC REPORTS

OF THE

Agricultural Research Institute, Pusa

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

1918-19

CALCUTTA
SUPERINTENDENT GOVERNMENT PRINTING, INDIA
1919

TABLE OF CONTENTS.

Scientific Reports of the Agricultural Research Institute, Pusa

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

1918-19

REPORT OF THE DIRECTOR.

(G. A. D. Stuart, I.C.S., and E. J. Butler, M.B., F.L.S.)

I. Charge and Staff.

Charge. Mr. J. Mackenna, C.I.E., I.C.S., held charge of the office of the Agricultural Adviser to the Government of India and Director, Agricultural Research Institute, Pusa, up to the 2nd October, 1918, and again from the 4th November, 1918, to the 12th April, 1919, when he proceeded on 6 months' privilege leave. Dr. W. H. Harrison acted as Agricultural Adviser and Director from the 3rd October to the 3rd November, 1918, and Mr. G. A. D. Stuart, I.C.S., assumed charge from the 13th April, 1919.

Dr. E. J. Butler, M.B., F.L.S., has been appointed Joint Director of the Institute, in addition to his duties as Imperial Mycologist, from the 20th January, 1919, and the appointment of the Assistant to the Agricultural Adviser to the Government of India held by Mr. Wynne Sayer, B.A., has been temporarily placed in abeyance from the same date.

Staff. Dr. E. J. Butler, M.B., F.L.S., Imperial Mycologist, was on deputation to the Federated Malay States, to report on the Agricultural Department there, from the

8th July to the 13th November, 1918. During his absence, Dr. F. J. F. Shaw, A.R.C.S., F.L.S., officiated as Imperial Mycologist, and Mr. J. F. Dastur, M.Sc., then First Assistant of the Mycological Section, acted as Second Imperial Mycologist. Mr. Dastur has since been appointed to the Indian Agricultural Service as Supernumerary Mycologist and deputed to England for fifteen months for training.

Mr. G. S. Henderson, N.D.A., N.D.D., was confirmed in the appointment of Imperial Agriculturist from the 1st March, 1918. On the termination of his temporary duties as Controller (Agricultural Requirements, Mesopotamia) under the Indian Munitions Board on the 22nd June, 1919, he proceeded on six months' combined leave. Mr. Wynne Sayer officiates as Imperial Agriculturist from the 20th January, 1919.

Mr. F. M. Howlett, B.A., F.E.S., Imperial Pathological Entomologist, was deputed for a period of 6 months from the 24th January, 1919, under the Indian Research Fund Association to conduct experiments with mosquito repellents.

Mr. J. H. Walton, B.A., B.Sc., on the termination of his duties under the Military Department, reverted to his appointment of Supernumerary Agricultural Bacteriologist on the 10th April, 1919. During Mr. Walton's absence of nearly four years he saw active service with the armies in Mesopotamia, Egypt and Palestine.

Captain W. Hodgkinson, R.E., worked in the laboratory of the Imperial Agricultural Bacteriologist throughout the year, in collaboration with that officer in electrical methods of water sterilization.

Mr. J. Sen, M.A., F.C.S., Supernumerary Agricultural Chemist, continued throughout the year on deputation under the United Provinces Government.

Mr. M. Afzal Hussain, B.A., M.Sc., who has been appointed to the Indian Agricultural Service, was posted to Pusa as Supernumerary Entomologist from the 6th January, 1919.

II. Work of the Institute.

Scientific work. The scientific work of the Institute during the year is described in the reports of the various sectional heads. The more important investigations were the following :—

On the Pusa farm, which is managed by the Imperial Agriculturist, besides carrying out manurial, rotational and varietal tests, the economics of steam cultivation are being studied. In view of the favourable reports of motor cultivation from home, a Fordson motor tractor was obtained during the year. A demonstration of its working was given in the presence of a large number of people from all parts of India. The tractor worked with implements in use on the farm and did all that it was asked to do in excellent style. Experiments are in progress to determine working costs, etc. The work on the breeding of pedigree herds of cattle is increasing in importance. Besides the pure Montgomery and half-bred Ayrshire × Montgomery herds, there are now three-quarter-bred, double cross-bred and quarter-bred calves on the farm. Careful observations and records are being kept with a view to collecting data as to hardiness, milk yield, etc., of the various crosses. A series of calf-rearing and feeding experiments are also in progress. During November, 1918, 169 cattle were inoculated against rinderpest by the serum simultaneous method, without any casualties. The demand for the surplus stock disposed of at the half-yearly sales was very brisk and high prices were realized.

In the Chemical Section, further investigation was made as to the value of Dyer's method in estimating available phosphoric acid when applied to calcareous soils. Attention was also directed to the retention of phosphoric acid in calcareous and non-calcareous soils. The influence of windrowing on the sugar content of sugarcane in the Peshawar valley and the direct and indirect action of green manures in relation to paddy cultivation were other important investigations in progress in this Section.

Besides creating new centres of distribution of Pusa 12 and 4 which are now preferred to the country wheats wherever they have been introduced, the Botanical Section reached during the year an important stage in the breeding of rust-resistant wheats. Many new forms which are characterized by strong straw, rust-resistance, good standing power and heavy yields have been fixed, and these are being tested on a field scale. The Howards' experiments in water saving in wheat growing have shown that if the texture of the soil has been improved and if the surface has been properly graded, extremely heavy crops are possible with a comparatively small volume of irrigation water. The agricultural side of the indigo problem continued to be studied in this Section. The effect of drainage on crop production and the pollination of Indian crops were some of the other lines of work on which Mr. and Mrs. Howard were engaged during the year.

The Ufra disease of rice, the black band disease of jute, sugarcane smut, the pigeon pea wilt and the diseases of chilli principally engaged the attention of the Mycological Section during the year under report. The various diseases affecting fruit trees are also under study in the orchards in the Kumaon hills, and spraying experiments are being carried out both there and in Peshawar.

In the Entomological Section, besides working in determining the relative immunity of certain varieties of cotton from bollworm attack and studying the borer pests of sugarcane and other graminaceous plants, special attention was paid during the year to the collection of information regarding fruit-pests. It has been ascertained that the "Tukra" disease of mulberry is caused by a mealy-bug, and that the affected apical leaves if fed to mulberry silkworms assist in inducing flacherie. The enquiry regarding the occurrence in the Indian Empire of any insects which may be used as efficient checks on the growth of *Lantana* was completed during the year and the results are being published separately. The work in connection with bees, lac and silkworms was continued.

Practically throughout the year, Mr. Howlett, Imperial Pathological Entomologist, was on special duty in connection, firstly, with the prevention of surra-transmission by Tabanidæ, more particularly among transport camels, and, secondly, with the improvement of existing culicifuges for military use. Reports on the work in these two directions have been submitted to Government.

Problems of soil biology under investigation in the Bacteriological Section during the year under review were :—(1) Seasonal variations in nitrification in soils under crop and fallow; (2) different rates of nitrification of various organic materials in soil; (3) inhibition of nitrification by toxins resulting from anaerobic incubation of soils; (4) green-manuring; and (5) fixation of nitrogen by legumes. Among enquiries of industrial value, Mr. Hutchinson, besides continuing his work on indigo and the pebrin disease of silkworms, succeeded during the year, in collaboration with Captain Hodgkinson, in producing a solution containing 3-4 per cent. available chlorine by electrolysis from purely Indian raw materials, for the sterilization of water. The solution can be prepared anywhere where electric current is available without expert knowledge either of chemical or electrical methods.

The work done by the Indigo Section is published in a special series of Indigo Publications started by the Institute. A separate annual report has therefore not been considered necessary.

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

	Number of students
General Agriculture	2
Agricultural Chemistry	1
Mycology	2
Economic Entomology	2
Agricultural Bacteriology (including bacteriological technique in silkworm disease)	2
Sericulture	4
Lac-culture	2
TOTAL	15

Besides the regular students, Mr. S. N. Bal, Assistant Professor of Botany, Science College, Calcutta University, spent about a fortnight in the Mycological Laboratory in March and April as he proposes to take up mycological work in Calcutta.

III. Publications.

Six Memoirs, 13 Bulletins (including three reprints and one vernacular version), and three Indigo Publications were issued during the year, while ten publications were in the press at the close of the year.

The demand for the Bulletin on "Insecticides, Mixtures and Recipes for use against Insects in the Field, the Orchard, the Garden and the House" continued, with the result that it had to be printed a third time during the year. A Bengali version of Bulletin No. 46 on Bee-keeping, written in language simple enough to be understood by the village folk when read by themselves or read out to them, was issued during the year and the whole edition rapidly sold out.

The Agricultural Journal of India in its new form continues to gain in popularity, and it became necessary during the year to increase the print order by 250 copies. It is proposed to issue the Journal bi-monthly, instead of quarterly, with the commencement of the New Year. All the present features will be maintained, but no increase will be made in the annual subscription.

IV. General Administration.

Buildings and works. The bungalow for the Electrical Engineer referred to in last year's report was completed during the year. The construction of quarters for the First Assistant to the Imperial Mycologist as well as for the staff of the Pusa High English School will be begun as soon as the necessary materials are available. Necessary funds have also been allotted for the construction of a building for the Post Office and a rest house for Indian visitors. A pumping set has been installed on the river

Gandak to tide over the period until a more satisfactory scheme of irrigation can be worked out.

Library. In addition to the 1,656 bulletins, memoirs, reports, books and reprints received in exchange, 457 new volumes were purchased during the year. A fourth edition of the catalogue of the library is in the press.

Pusa School. The total number of pupils attending the Pusa High English School on the 30th June, 1919, was 192 as against 160 on the corresponding date of last year. Of the 11 students sent up for the Matriculation Examination of the Patna University, seven were successful.

General health of the station. Although the neighbouring villages suffered severely with the rest of India from the influenza epidemic, it was noteworthy that the number of cases on the Pusa estate were relatively few and there was not a single death. This was not a little due to the precautionary measures taken by the Medical Officer, Mr. S. Gupta, and his staff, who deserve great credit. Medical relief was afforded to 19,938 out-patients and 203 in-patients in the hospital and dispensary attached to the Institute during the year under report.

V. Accounts.

The total expenditure during the financial year 1918-19 was Rs. 6,06,640, as against Rs. 5,81,723 during the previous year. The details are given below :—

	Rs.
Office of the Agricultural Adviser and Director	2,35,301
Chemical Section	38,129
Mycological Section	42,954
Entomological Section	55,073
Pathological Entomological Section	38,131
Bacteriological Section	32,860
Botanical Section	50,327
Agricultural Section	63,594
Indigo Research Section	50,271
Total	6,06,640

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 corn crusher	655
Purchase of a chaff cutter	596
Purchase of canvas paulins for the Pusa Farm	652
Paid to the Director of Agriculture, Bengal, for the cost of a mechanical fibre extractor	1,457
Experimental cotton cultivation by the Imperial Cotton Specialist	1,200
Pay of a Veterinary Assistant in connection with cattle breeding and that of a Fieldman for mosquito experiments	1,431

The gross receipts during the year from the sale of farm produce, milk, publications of the department and other articles amounted to Rs. 21,403 as against Rs. 19,843 in the previous year.

VI. Conferences.

The Government of India having accepted the recommendation of the tenth meeting of the Board of Agriculture in India held at Poona in 1917 that sectional meetings of mycologists, entomologists and chemists be held in years in which there is no meeting of the Board of Agriculture, such meetings were held at Pusa in February, 1919. In accordance with the recommendation of the Board, they were not confined to members of the Agricultural Department. The Indian Tea Association and Portuguese India were represented at both the Mycological and Entomological Meetings, whilst the Forest Zoologist attended the Entomological Meeting. The latter meeting also attracted visitors from outside India, the Egyptian Government sending an official delegate in Dr. Lewis H. Gough, Director of the Entomological Service in Egypt, and Mr. R. Senior-White attending from Ceylon. Detailed proceedings of these meetings are being issued.

A cattle conference was also held at Pusa during the year, when several problems connected with the Pusa dairy herd were discussed.

VII. Visitors.

The most notable visitor during the year was His Excellency the Viceroy. This was the first time that the Institute was honoured by a visit from a Viceroy. Lord Curzon had previously visited Pusa, but he came only to lay the corner stone of the splendid building which houses the various laboratories of the Institute. His Excellency Lord Chelmsford, who was accompanied by the Hon'ble Sir Claude Hill, Member in charge of the Revenue and Agriculture Department, spent three busy days (4th to 6th January) in going over the various Sections and evinced much interest in all that he saw.

In all about 165 ladies and gentlemen visited the Institute during the year. These included :—

Lieutenant-Colonel F. H. G. Hutchinson, M.B., I.M.S., Sanitary Commissioner with the Government of India; Dr. C. A. Bentley, M.B., D.P.H., D.T.M. & S., Sanitary Commissioner to the Government of Bengal, Mr. P. J. Hartog, C.I.E., M.A , B.Sc., L-es-Sc., Academic Registrar of the University of London and Member of the Calcutta University Commission; Professor C. V. Raman, M.A., Palit Professor of Physics, Calcutta University; Mr. A. B. Shakespear, C.I.E., of Messrs. Begg Sutherland & Co., Cawnpore; Mr. G. E. C. Wakefield, O.B.E., Director General of Industries, Agriculture and Commerce, Hyderabad (Deccan); Lieutenant-Colonel Milton, Assistant Director of Grass Farms, Meerut; Lieutenant-Colonel J. Matson, Assistant Director of Military Farms, Northern Circle, Ambala; Major V. B. Nesfield. F.R.C.S., I.M.S.; Captain Froilano de Mello, Director of the Bacteriological Laboratory, Goa, Dr. L. H. Gough, Director of the Entomological Service, Egypt; Mr. S. Higginbottom, Director of Agriculture, Gwalior; Mr. C. F. C. Beeson, M.A., Forest Zoologist, Forest Research Institute, Dehra Dun; Mr. J. C. Nag, Senior Professor of

Botany, Presidency College, Calcutta; Mr. E. A. d'Abreu, F.Z.S., Curator of the Central Museum, Nagpur; Mr. C. C. Monckton, of Nairobi; Mr. R. Senior-White, F.E.S., Matale, Ceylon; Kumar Chandreswar Prasad Narayan Singh of Sursand and Syed Shafael Hussain of Gaya.

Among other visitors were officers of the various Provincial Departments of Agriculture, and planters and zamindars of estates surrounding Pusa. A party of students from the Sabour Agricultural College, under two Assistant Professors, also visited the Institute during the year.

REPORT OF THE IMPERIAL AGRICULTURIST.

(Wynne Sayer, B.A.)

I. Charge and Training.

I was in charge of the Farm, in addition to my duties as Assistant to the Agricultural Adviser, up to the 20th January, 1919. From that date I have been officiating as Imperial Agriculturist.

Training. Mr. Kalyan Mal Banthia was under training in agriculture and cattle work during the year.

B. Dalip Singh, an Overseer from the Karnal Military Dairy Farm, was admitted to a course of six months' practical agriculture on the farm from 30th May, 1919.

Conference. A Cattle Conference was held at Pusa on 17th and 18th February, 1919, when several matters connected with the Pusa herd were discussed.

II. Pusa Farm.

The Season. The year 1918-19 was remarkable for early rain in May followed by a heavy rainfall for the year, 60·19 inches being registered as against 45·54 inches for last year. But the distribution was so uneven that it was by no means a good year. The failure of the *hathia* in October told heavily upon the *rabi** crop which was only saved from disaster by a short rain in January, too late, however, to affect the main crop to an appreciable extent. Floods started on the 1st June which is unusually early, and heavy rain on the 25th and 26th of August accompanied by strong winds laid most of the maize, and, in short, the record of the whole season goes to prove that it is the distribution far more than the actual quantity of rain that counts from an agricultural point of view.

* Crop sown in winter.

I give below the rotation under which the farm is worked, and a reference to the plan of the arable area printed opposite will assist the reader.

	1st year	2nd year	3rd year
Kharif*	Maize for silage and fodder	Maize for corn	Pulse green crop
Rabi	Oats .	Rahar (*Cajanus indicus*)	Oats

* Crop sown in monsoon.

The object of this rotation is to work the land to the best advantage and provide grain and fodder for the herds.

The cattle are soiled on the third year pulse crop and this practice is showing good results on the higher lands.

The cropping of the various fields on the farm is shown on the plan and is here dealt with in detail.

By arrangement with the Controller of Agricultural Requirements for Mesopotamia, Poona, an extra area was put down under oats in order to provide seed for Mesopotamia.

1st year rotation. A dressing of 10 tons farmyard manure or 10 maunds cake is given and the land is put under maize or *juar* (*A. Sorghum*) for silage or fodder followed by oats in the *rabi.*

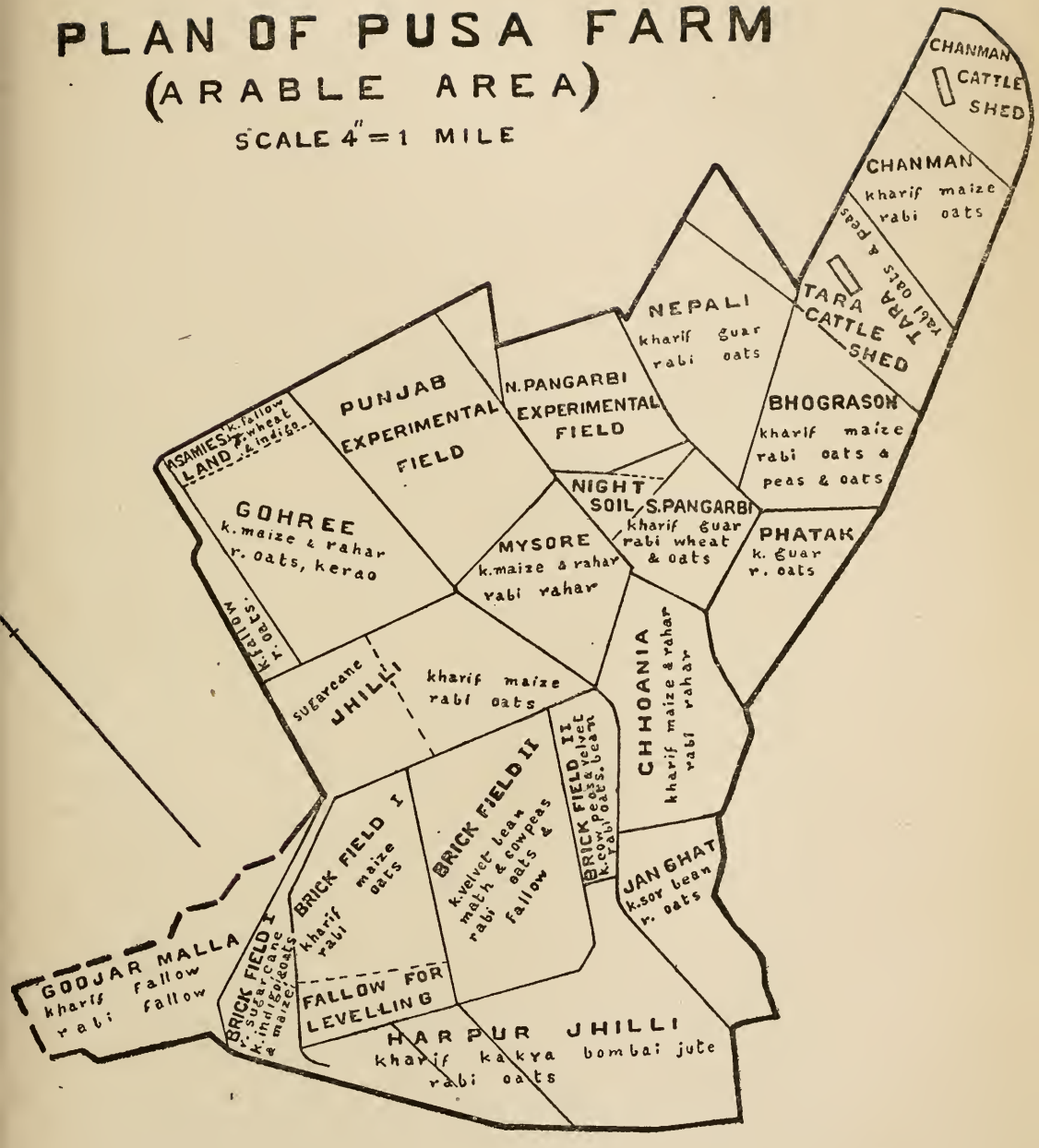
Four fields aggregating 132 acres were sown with maize and *juar.* The best yield was from Chanman where 17 acres gave 344 maunds per acre, and the average yield throughout was 200 maunds per acre. The same fields under oats in *rabi,* with the exception of 16 acres left fallow for levelling, gave an average yield of 14 maunds per acre, the best yield being 16 maunds per acre from Brickfield No. 1.

The working costs for the year for both crops came to Rs. 43 per acre and the return Rs. 130, giving a working profit of Rs. 87† per acre for the year.

† This does not include rents, rates and taxes or charges for supervision.

PLAN OF PUSA FARM
(ARABLE AREA)

SCALE 4" = 1 MILE



2nd year rotation. No manure is given here. Maize and *rahar* are sown together and the *rahar* stands for the *rabi*, thereby saving us a considerable amount of cultivation at the busiest time of the year. One hundred and thirty-three acres were sown, 93 standing under maize and *rahar* and 40 under jute which is grown for the Fibre Expert and is taken in the second year rotation. Cultivation costs were Rs. 23 per acre for the year, and the return Rs. 100, giving a profit of Rs. 77.

This was a good year for *rahar* and the best field Gohree gave $14\frac{3}{4}$ maunds, and the average over all was nearly 12 maunds. The maize did badly owing to heavy rain at the wrong time, and the best yield was only $10\frac{1}{2}$ maunds per acre from Gohree. As is usually the case with crops sown together, we made on one what was lost on the other, a most important thing considering the large number of cattle dependent on the farm for grain.

3rd year rotation. Here pulse crops are sown in *kharif* for feeding off on the land. One hundred and thirty-four acres were put down under *guar* or cluster beans (*Cyamopsis psoralioides*), soy beans, cow peas, velvet beans and *math* (*Phaseolus aconitifolius*), and the cattle were penned on a small area daily. The early flooding of the *dhab* grazing area brought the cattle on to the soiling crops early in the season and by close hurdling the whole area was thoroughly gone over, 230 head of cattle being put on an average of 1·13 acres daily and the soiling continuing for 78 days. *Guar* is the most satisfactory pulse for soiling. Cattle eat it readily and it is not difficult to bury green, while it smothers the land satisfactorily while standing. The usual troubles of hurdle breaking and hoven were in evidence and the young cross-bred bulls were troublesome when near the cows, but the results on the land and succeeding crops fully justified the close soiling, and it is to be recommended to any one who runs a herd of cattle in connection with an arable farm, the saving in labour of cutting and carting the green crop alone being considerable. A decent hurdle not too heavy

and yet strong enough to stop cattle has yet to be evolved. Ideal fencing was tried and proved useless while bamboos were much too light.

Oats followed the pulse crop over 105 acres, a small area being in wheat. One maund of superphosphate was given at the time of sowing. The best yield was 19 maunds an acre from Phatak and Nepali fields and the average yield was 15 maunds. Wheat averaged 13 maunds per acre on the whole area. Working costs were Rs. 26 per acre and the return Rs. 93.

Sugarcane. The usual area, 8 acres, was put under cane and 16 varieties were planted. The cane is grown without irrigation, 27 maunds of rape-cake being applied per acre, half given at planting and the remainder at first ridging on the break of the monsoon. The cane yield averaged 611½ maunds per acre and was sold green at 8 annas per maund to the factory direct.

The cost of cultivation was Rs. 126 per acre and the return Rs. 305.

Sixteen varieties were grown. Among the thick canes were Sathi, Purple Mauritius and Kaludai Budan; while J. 33, J. 36, Mungo, Yuba and Saretha did well among the thin varieties.

Twenty-three varieties from Dr. Barber, Government Sugarcane Expert, were also grown for comparative tests and those that did well are being tried on a larger scale. All cane planting, except placing the setts and manure in the furrow, is done by bullocks and the saving in labour is considerable, while the return made on this area shows clearly that cane grown in this fashion will do well; the thick varieties in particular averaging out excellently.

Jute is grown on the farm for seed by arrangement with the Fibre Expert and the seed after being treated with copper-sulphate is sent out to Bengal. Till last year the crop was grown on the main area of the farm but as it was impossible to spare this class of land from fodder crops for the cattle it was sown this year in Goojarmalla, a field liable to be flooded, being outside the protective embankment, and

therefore unable as a rule to hold a *kharif* crop. This being the first year jute has been sown there, the season has retaliated by being exceptionally free from floods. It looks however as if the present arrangement will have to terminate as the whole area is required to meet the ever increasing needs of the farm herds.

Experimental work. This work was continued in the two fields, Punjab and North Pangarbi, set apart for the purpose.

(*a*) The permanent manurial and rotational experiments were continued. A proposal for discussion of all results so far obtained and consideration of the question of the continuance of the experiments has been placed on the agenda at the next meeting of the Board of Agriculture when the matter will be thoroughly dealt with.

(*b*) The green-manuring experiments, run in collaboration with the Imperial Agricultural Bacteriologist, were carried a step further in the testing of the residues. The yields from the different plots from the beginning are given below :—

Particulars	Yield of oats (grain) per acre in 1917	Yield of green maize per acre in 1918	Yield of oats (grain) per acre in 1918	Particulars	Yield of oats (grain) per acre in 1917	Yield of green maize per acre in 1918	Yield of oats (grain) per acre in 1918
	After green manure	After oats	After maize		After green manure	After oats	After maize
	lb.	lb.	lb.		lb.	lb.	lb.
3 times san-hemp fermented with 3 cwt. superphosphate per acre.	1,977	21,748	1,131	3 times san-hemp fermented without superphosphate.	1,485	21,091	1,168
6 times san-hemp fermented with 3 cwt. superphosphate per acre.	2,643	29,501	1,564	6 times san-hemp fermented without superphosphate.	1,561	27,793	1,094
San-hemp ploughed in with 3 cwt. superphosphate per acre.	2,080	20,960	764	San-hemp ploughed in without superphosphate.	1,259	20,861	690
Superphosphate alone at 3 cwt. per acre without green manure.	1,185	20,196	554	No superphosphate and no green manure. (There are 3 such plots. Average of these entered.)	1,040	18,395	666

Should the maize yields this season show that the plots are still holding a residue, the entire series will be put under oats in *rabi*.

(*c*) The experiments, in collaboration with the Imperial Mycologist, regarding a method of dealing with "die-back" in chillies were continued.

(*d*) Twenty-three varieties of wheat from selected strains were under trial. The average yield per acre from all varieties was $15\frac{3}{4}$ maunds but a great deal of rust was observed on several varieties, those from Jubbulpore being especially bad.

Late ripening also put several other varieties out of court.

The best yields were as follows :—

	Mds.	Seers
8A Lyallpur	26	...
Sindhi Pissi	22	27
Maroo Booji (Sindhi)	20	28
Lal of Jhelum	19	37
Pusa 12	19	31
Federation	16	37

Federation which was said to be too late in ripening for Bihar, distinguished itself by being ripe at the same time as Pusa 4. It was harvested from 16th to 21st March, while Pusa 4 was harvested between 13th to 20th March. But its yield was disappointing and further tests will be carried out in which the new variety of improved Federation (Hard Federation) which is said to be a distinct improvement on the present wheat will be tried. Much interest was taken in the 2 acres of Federation grown on the farm and seed has been given out to several planters and also to the Director of Agriculture, United Provinces, for trial. The stiffness of its straw is one of its most noticeable points. I have myself seen a big block of this wheat which ultimately gave 40 maunds per acre, standing after heavy wind and rain without a straw down; and as a stiff straw is an essential for a heavy yield, this wheat will

be found capable of giving a big return on lands which will lay other wheats.

(*e*) The experiments for testing yields of green fodder with yields of seeds and comparative economic value of the common leguminous crops were continued. There are two series in this experiment. One series is grown to produce green fodder in *kharif* and is followed by winter pulses for seed in *rabi*. The second series is for seed of both *kharif* and *rabi* pulses.

"A" Series.

Kharif pulses	Green fodder per acre in lb.	How dealt with		Rabi pulses	Weight of seed in lb. per acre
		Fed to cattle	Left by cattle		
Florida velvet beans	13,670	$\frac{3}{4}$	$\frac{1}{4}$	Lentils	1,394
Florida Beggar weed	4,846	$\frac{1}{3}$	$\frac{2}{3}$	*Dolichos Lablab*	926
Cow peas	10,184	$\frac{2}{3}$	$\frac{1}{3}$	White peas	536
Soy beans	7,145	$\frac{4}{5}$	$\frac{1}{5}$	Purple peas	1,064
Cluster beans	12,106	$\frac{2}{3}$	$\frac{1}{3}$	Gram of Gujarat District	1,645
Dolichos Lablab	1,643	$\frac{2}{3}$	$\frac{1}{3}$	Gram, local	1,848
Urid (*Phaseolus radiatus*)	11,868	$\frac{10}{11}$	$\frac{1}{11}$	Gram, Cabuli small	1,343
Math	17,905	$\frac{12}{13}$	$\frac{1}{13}$	Gram, Cawnpore	1,185

"B" Series.

Kharif pulses	Weight of seed per acre in lb.	Rabi pulses	Weight of seed per acre in lb.
Florida velvet beans	928	Fallow as velvet beans were harvested late.	..
Florida Beggar weed	47	Purple peas	838
Cow peas	267	Gram Cawnpore	963
Soy beans	1,224	Fallow as soy beans were harvested late.	..
Guar	772	Gram, small Cabuli	805
Val (*Dolichos Lablab*)	528	Val (*Dolichos Lablab*), same crop standing in rabi.	..
Urid	207	Gram, local Orai Farm	382
Math	1,022	Gram of Gujarat District	435

In series "A," of the *kharif* pulses the best is *math* both in feeding value and weight of crop. *Urid* is next and then *guar*. Florida velvet beans make a big crop but fall

off in feeding value. Florida Beggar weed is a wash-out at Pusa. Soy beans are moderate while *Dolichos Lablab* does not do. In *rabi* pulses gram comes first followed by lentils and purple peas.

In "B" series, as regards *kharif* pulses the highest yield of seed was got from soy beans, but this crop holds the land in *rabi* also, which puts it out of consideration.

Florida velvet beans and Florida Beggar weed are poor yielders. *Urid* and *Dolichos Lablab* are also poor. The *rabi* pulses were purple peas and gram. They were sown late as the *kharif* crop occupied the ground till late. If sown at the proper time, I think the result would have been equal to those of "A" series.

(*f*) Experiments with Java and Sumatrana indigo were carried on in collaboration with the Indigo Research Chemist and Imperial Agricultural Bacteriologist. As mentioned in last year's report, these will be continued over a period of years and the results will be dealt with from time to time by the Indigo Research Chemist and the Imperial Agricultural Bacteriologist in their respective reports.

As in past years, crops for the various experts were grown in North Pangarbi. Experiments on *rahar* wilt referred to in last year's report were carried out in collaboration with the Imperial Mycologist and the Fibre Expert. They will be continued next year.

Buildings and Machinery. The new silage cutter—Climax—referred to in last year's report, was worked throughout the season and cut 12,000 maunds of silage. It has proved itself a thoroughly reliable, serviceable machine, and, when worked in connection with a tractor, forms one of the handiest silage cutting outfits it is possible to have on a farm.

The 4′ 6″ Marshall's thresher turned out no less than 513 maunds of cleaned oats in a day, thus beating last year's record of 505 maunds. Regular feeding and a total absence of any stops except those for oiling enabled us to work off

4,932 maunds of various grains such as oats, wheat, gram and *rahar* in 36 days and finish by the 23rd April, thereby escaping all damage from the early rain in May, a result which reflects the greatest credit on all concerned and shows what can be done with machinery in India.

Steam Ploughing Tackle. The set of tackle consists of two single cylinder K Class Fowler engines with 900 yards steel wire rope and a four furrow anti-balance gang plough, a disc harrow, a grubber, a zigzag harrow and a Crosskill roller. The cost of purchase in 1913 was as follows :—

	Rs.
Two engines with steel cables	30,000
Plough	3,700
Disc harrow	3,625
Grubber	3,227
Zigzag harrow and roller	2,925
TOTAL	43,477

The tackle worked in the season 1918-19 for 145·4 days, the working day being reckoned at 10 actual working hours. The tackle stood idle during the remainder of the season.

Details of output, consumption and costs including all expenses except depreciation and interest on outlay are given below.

Statement A.

Output, consumption and cost of steam tackle during 1918-19.

(a) *Output.*

Year	Working days	Summary of work done										Average acres per day			
		Ploughing		Disc harrowing		Grubbing		Rolling		Total		Ploughing	Disc harrowing	Grubbing	Rolling
		Days	Acres	Days	Acres	Days	Acres	Days	Acres	Days	Acres				
1918-19 . .	145·4	50·65	373·5	36·90	605·5	32·20	668·0	25·65	540·0	145·4	2187	7·3	16·4	20·7	21·0

(b) *Consumption.*

Year	Days	Coal and wood						Engine oil			Cylinder oil			Grease			Waste		
		Total			Per day														
		Mds.	Srs.	Ch.	Mds.	Srs.	Ch.	Mds.	Srs.	Ch.	Mds.	Srs.	Ch.	Mds.	Srs.	Ch.	Mds.	Srs.	Ch.
1918-19 . . .	145·4	4,675	10	0	32	6	0	12	4	10	4	8	6	1	0	0	1	35	5
		109	25	0	0	30	0												
		4,784	35	0	32	36	0												

(c) *Cost.*

Year	Days	Analysis of working cost					Working cost per acre			
		Labour*	Coal and wood	Lubricants and wastes	Total	Per day	Ploughing	Disc harrowing	Grubbing	Rolling
		Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.
1918-19	145·4	933 10 9	1,655 13 9	481 14 9	3,071 7 3	21 2 0	2 14 4	1 4 7	1 0 4	1 0 1

* Labour constitutes the wages of two drivers, two firemen, two implement men, and water and coal carriers.

Year	Days	Up-keep and duplicates	Inspection fee	Total expenses	Total cost per acre			
					Ploughing	Disc harrowing	Grubbing	Rolling
		Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.
1918-19	145·4	789 4 1	275 0 0	4,135 11 4	3 14 4	1 11 9	1 6 0	1 5 8

STATEMENT B.

Showing cost for working and maintaining the tackle in 1916-17, 1917-18 and 1918-19.

Particulars	1916-17 No. of working days 151	1917-18 No. of working days 121	1918-19 No. of working days 145·4
	Cost	Cost	Cost
	Rs. A. P.	Rs. A. P.	Rs. A. P.
Labour	1,233 0 0	940 1 6	933 10 9
Coal	1,788 0 0	1,424 9 0	1,655 13 9
Oil	300 0 0	315 0 0	481 14 9
Miscellaneous stores, etc., and renewals	713 0 0	3,418 13 9	1,064 4 1
TOTAL	4,034 0 0	6,098 8 3	4,135 11 4

Statement C.

Showing the above costs divided into following operations per acre in the year 1916-17, 1917-18 and 1918-19.

Particulars	1916-17			1917-18			1918-19.		
	Total area cultivated in the year	Cost per acre	Best day's work	Total area cultivated in the year	Cost per acre	Best day's work	Total area cultivated in the year	Cost per acre	Average per day
	Acres	Rs. A. P.	Acres	Acres	Rs. A. P.	Acres	Acres	Rs. A. P.	Acres
Ploughing	267	4 6 2	7	170·5	9 3 2	7	373·5	3 14 4	7·3
Disc harrowing	498	2 0 9	18	821·5	3 0 3	20	605·5	1 11 9	16·4
Grubbing	1,080	1 7 4	25	616·0	4 5 7	26	668·0	1 6 0	20·7
Zigzag harrowing . . .	41	0 14 9	27	11·0	2 2 6	...	...	...	...
Rolling	320	1 5 6	22	173·0	3 14 0	22	540·0	1 5 8	21·0
Total .	2,206		...	1,792		...	2,187		...

It will be seen from the Statements B and C that the cost of operations is now at the 1916-17 level, and that the 1917-18 figures may be taken as abnormal owing to war conditions. The entire tackle is in thorough working order and, with the rigid system of replacements practised, may be calculated to be as good as when first purchased. The work done by it is excellent, but the heavy capital cost still remains a drawback to its general adoption on estates, and it is to be feared that this cost will never revert to pre-war figures.

A Fordson motor tractor (Plate I) was bought in May, and a demonstration of its working was given on the farm. As this was the first tractor of its type to be worked in India, much interest was displayed in the demonstration and a large number of people attended from all parts of India.

The tractor worked with implements in use on the farm and did all that it was asked to do in excellent style. It was hitched successively to a double furrow disc plough, a Ransome's cultivator, Cambridge roll and rake of three spring tooth-harrows, and afterwards was used to run the silage cutter. One could not fail to be struck with its work over ploughed land which was good, thorough, and showed no sign of poaching the land or failing to get a driving grip. Its weight 21 cwt. all on appears to be the optimum for these operations. It is an extraordinarily handy machine and, with its light weight and great power, is well adapted to Bihar conditions. It is now working regularly on the farm and careful records are being kept of its fuel consumption, etc. A report will be issued in due course, and I take the opportunity of stating here that pending the completion of thorough trials and the issue of this report, I am not prepared to express any definite opinion as to its capabilities. Any one wishing to see it working is welcome to do so. It is hoped to be able to run parallel experiments with other types of tractors this winter; and also to test fully the various types of implements provided with these tractors, and there seems little reason to doubt

FORDSON MOTOR TRACTOR: VIEW OF ENGINE FROM INTAKE SIDE

PLATE I.

that many improvements can be made which will increase the capacity and efficiency of these tractors on Indian soils and thereby enable them to deal with a much larger area at a lower cost per acre. But to carry out all this work successfully, the co-operation of an engineer with agricultural knowledge is essential, and close collaboration with makers both of tractors and implements is essential and, when established, should prove of inestimable benefit to both sides. The low capital cost of these machines and their extreme handiness will render them admirably suited for Indian conditions, provided that they prove capable of withstanding the amount of ill usage which all machinery of this type will have to put up with in the hands of a race who make all adjustments with a hammer and all running repairs with a piece of string. The outlook at present for these machines is most promising, and I consider that they will make a big difference to agriculture in many parts of India if their early promise is fulfilled.

Miscellaneous. Seven hundred maunds of seed oats and 81 maunds of peas were supplied to Mesopotamia for seed purposes. This entailed a large amount of extra work in screening, cleaning and packing which the farm staff cheerfully undertook, and the whole consignment was despatched in record time and condition—an excellent achievement for which I take this opportunity of thanking all concerned.

III. Cattle-Breeding.

The combined herds totalled 372 head in the year under report.

It will possibly be advisable for the benefit of those who have not read former reports to state here the objects for which the two herds are maintained.

The Montgomery herd is divided into two portions—

(*a*) For selective breeding for milk production. The cows here are divided into five groups each with a separate bull; and the object is to breed up a first class milking strain in each group and thereby establish the breed without fear of in-

breeding. All the best milkers in the Montgomery herd are included in these groups.

(*b*) For crossing with the Ayrshire bulls. The cows here are not sufficiently good for inclusion under (*a*) and are used for putting to the Ayrshire bulls for the cross-bred herd.

The policy of strict selection for milk yield is being continued throughout the Montgomery milch herd and the best records among the cows in it this season were as follows:—

	lb.
Imani	5,654
Saheji	5,111
Anjani	4,953
Ladli	4,852

All Montgomery cows calving down for the first time are now being treated in English fashion, their calves being removed at birth and put on the pail. No difficulty whatever has been experienced in milking these cows without their calves, and I think this has given a pretty heavy blow to the idea that the indigenous cow will not give milk without a calf. Once she has acquired bad habits she is undoubtedly troublesome, but if her calf is removed at birth from her first calving she is as easy to deal with as an English cow, and if this practice is adopted by all who have heifers calving down they will save themselves much trouble. In two of the above cases calves have died, being weakly at birth. The advantage of having the cows continue giving milk instead of immediately going dry, as is the rule in such cases ordinarily, is too obvious to need emphasizing. I am also of opinion that possibly the tendency in Montgomery and indigenous cattle to stand off the bull throughout the milch period may be attributable to having the calf at heel, and it will be possible to collect some data on this point from the above experiments. They will also be of the greatest use in enabling us to start a set of absolutely reliable milk records. Our present method of averaging the teat the calf is allowed to suck is by no

Fig. 1. Double cross cow-calf of Kitty No. 10; five months old.

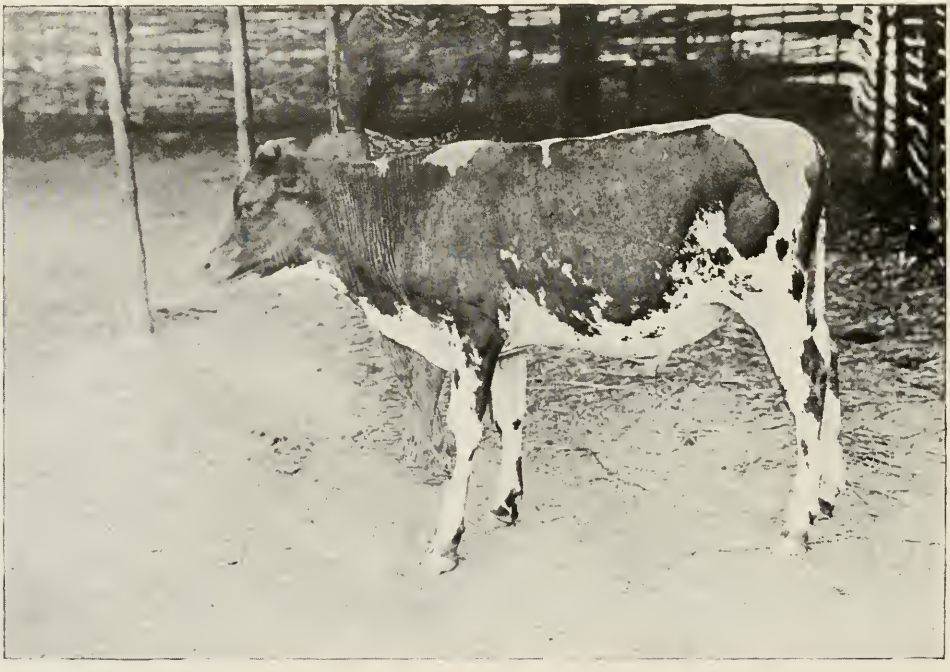


Fig. 2. Double cross bull-calf of Dollie No. 20; five months old.

means really reliable or accurate when it comes to a question of keeping proper milk records.

The Montgomery-Ayrshire cross-bred herd now stands at 73 head.

The heifers and cows in the herd are put to cross-bred bulls of which there are three with the herd :

(1) Black Diamond No. 3, by Mossgeil Titanic, out of Rengni No. 149.
(2) Goliath No. 8, by Lessnessock Wildfire, out of Diwali No. 77.
(3) Mammon No. 9, by Lessnessock Wildfire, out of Timki No. 80.

The Mossgeil half-bred bull is used on Lessnessock heifers and the Lessnessock half-bred bulls on Mossgeil and Carston heifers. A Carston half-bred bull will be added to the herd in place of one of the Lessnessock bulls as soon as possible.

We have now calves from the following crosses, and careful observations and records will be and are being kept with a view to collecting data as to hardiness, milk yield, etc.

Half-bred	Ayrshire bull × Montgomery cow.
Three-quarter-bred . . .	Ayrshire bull × Ayrshire-Montgomery cow.
Double cross-bred . . .	Ayrshire-Montgomery bull × Ayrshire-Montgomery cow.
Quarter-bred	Ayrshire-Montgomery bull × Montgomery cow.

Plate II shows two typical double crosses at five months, and Plate III, fig. 1 a three-quarter-bred at five months.

At present it appears that three-quarter-breds usually have a longer, thicker coat, and are apt to be rather slower doers at first than half-breds. They, however, do quite well in the later stages. It is practically impossible now to distinguish between half-breds and quarter-breds and, as far as the experiments have gone, it appears evident that

the half English blood in the half-bred bull is sufficient to produce the same English characters as regards appearance and build as the full English and it will be of interest to see if this holds good when tested at the pail.

The double cross-breds are in all points similar to half-breds and do equally well. The first lot of three-quarter-bred crosses which went through the December inoculation had a pretty stiff time which pulled them back a lot; but they are now doing well.

Experiments with half-bred bulls and country cows are now in progress, and this should enable us to collect data which will probably confirm results arrived at with the Ayrshire × Montgomery and pure Montgomery cross. The undoubted milking powers possessed by Montgomery cows being liable to mask any possible improvement in milk yield introduced by half-bred bulls which would probably show clearly in stock got from an ordinary country cow of a poor milking breed.

The full lactation yields for the six half-bred cows from Mossgeil Titanic were as follows and fully bear out the remarks made about them in last year's report :—

	lb.
Alibi No. 3	7,271
Daisy ,, 5	6,763
Naomi ,, 1	6,406
Pansy ,, 4	5,345
Nancy ,, 6	4,454
Biddy ,, 2	3,862

The yield of the last two cows was considerably reduced, by udder trouble in the first case while Biddy is shy of a teat.

These cows have now calved again and are, with the exception of the last two noted above, milking excellently.

Six Lessnessock Wildfire heifers have calved and are now giving an average of 18-20 lb. per day.

One Carston Royal Scotch heifer calved on 7th March, 1919, and is now milking well. The remarkable evenness of yield shown by all these heifers whether got from cows

Fig. 1. Three-quarter-bred bull-calf of Biddy No. 2, five months old.

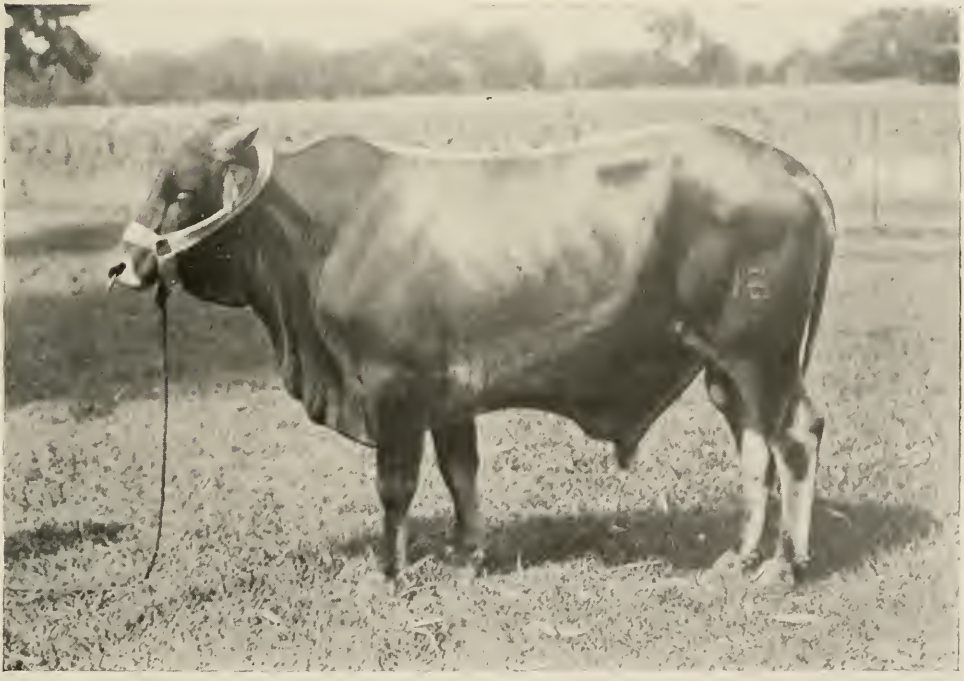


Fig. 2. Half-bred Ayrshire-Montgomery bull sold to the Hyderabad State.

A BUNCH OF THREE-QUARTER AND DOUBLE CROSS CALVES.

PLATE IV.

with good or bad milk records is a testimony to the potency of the English cross as regards milk production.

A series of calf rearing and feeding experiments have been started, and already show that half the usual quantity of milk fed to a calf during 10 months' lactation period, if given to the calf in the first five months only, grows a bigger, better calf at a far less cost. Plate IV shows a bunch of calves all taken clean off milk at five months. They are as big and strong as calves of 10 months and have been grown on half the quantity of milk fed to 10 months' calves which with milk at its present price is a big saving.

The usual couple of biennial sales were held in December, 1918, and April, 1919.

Seventy animals in all came under the hammer and realized a total of Rs. 11,850, averaging as follows :—

	Average price Rs.
Montgomery bulls	215
Montgomery cows	174
Montgomery bull-calves	126
Montgomery heifers	117
Ayrshire-Montgomery bull	500
Ayrshire-Montgomery heifers	455
Ayrshire-Montgomery bull-calves	146

Plate III, figure 2 shows a cross-bred bull sold to Hyderabad State for Rs. 500. These sales have now become an established custom, and the demand for all stock is so keen that I must again warn intending buyers to arrange to arrive in good time for sales.

At present every young bull I have to sell is being enquired about and Rs. 600 has already been offered in several cases.

Simultaneous inoculation. In December the whole of the young stock and all bulls—English, Montgomery and half-bred—together with all cows not heavy in calf were inoculated against rinderpest by the serum simultaneous method by Mr. Shilston, 169 animals being done. The

whole thing was a complete success in every way, and I take this opportunity of expressing my thanks for the invaluable assistance rendered by Mr. T. D'Sylva and the staff of the Power House, who stepped into the breach caused at the last minute by the strike of the entire *gowala* staff on religious grounds, and enabled me to carry out the inoculation. The way in which the staff turned to and soon proved that they could drive and stoke cattle as well as engines, enabled me to deal with the strikers drastically and future strikes of this nature are now extremely unlikely. A special inoculation camp was erected on the river bank at the most distant spot in the grazing grounds and cattle and attendants were kept there for the period of some six weeks.

The whole of the cattle were successfully inoculated and it was even found possible to save two of the control animals. The rest of the herd will be done this cold weather.

The sudden death of Mr. A. W. Shilston at Naini Tal from glanders was learnt with the deepest regret by the farm staff here, who had, during their month's work at the inoculation camp, every opportunity of seeing and experiencing the way in which Mr. Shilston carried on his work, and feel the loss occasioned by his death as keenly as those who had worked with him constantly.

Two young Montgomery bulls were introduced into the herd from the Military Dairy Farm at Ferozepore bringing in a much needed change of blood, and two Montgomery cows, one bull, and four calves were purchased from Bolpur. Various new buildings, including a set of calving pens and a building for the young male stock, were erected, and the thorough repair of the old buildings was started.

The general health of the herd was excellent and there was no outbreak of contagious disease during the year under record. I should like to take this opportunity of expressing my thanks to Khan Bahadur Judah Hyam who retires from Government service this August. He has had charge of the herd from the beginning and has seen it grow

into what is now the most famous herd of its kind in India, and it is in no small measure due to his care and experience in dealing with all forms of disease that it has been possible to bring such a state of things to pass, as a single outbreak of one of the more deadly forms of contagious disease would have easily destroyed ten years' work. And if there is one thing that constantly requires to be dinned into the ears of the owners of herds as well as subordinates in charge of them in this country, it is the necessity for extreme vigilance with stock uninoculated by the serum simultaneous method, and the necessity of taking prompt and effective measures against outbreaks of disease.

I give here the usual balance sheet for the breeding herd :—

Returns	Rs.	A.	P.	*Cost*	Rs.	A.	P.
Received for sale of milk .	6,677	13	3	Budget for upkeep . .	7,948	9	5
33 head sold in December auction	5,400	0	0	3,176 mds. 15 srs. grain at Rs. 3-8 per md. . .	11,117	5	0
37 head sold in April auction	6,450	0	0	Oil cake . . .	807	0	0
Sheep and cast stock . .	499	12	0	7,311 mds. green fooder at As. 4 per md. . .	1,827	12	0
TOTAL .	19,027	9	3				
Net cost	6,279	7	2	6,466 mds. *bhusa* and dry maize stalks at As. 4 per maund . . .	1,616	8	0
	25,307	0	5	5,306 mds. 13 srs. silage at As. 6 per md. . .	1,989	14	0
				TOTAL COST .	25,307	0	5

There was a considerable increase in the price of grain during the year, and that used for feeding cattle which was valued at Rs. 2-8 per maund in previous reports, has been charged for at Rs. 3-8 per maund this year.

The milk valuation, however, remains extraordinarily low at 10 Lahori seers (25 lb.) to the rupee. Cattle sales realized Rs. 11,850 for seventy animals which is a slight indication of the real value of the herd, as we naturally

keep the best stuff to breed from. The only conclusion which can be drawn from the above is that we have here a herd of great value which has now reached a stage in which it fully repays every rupee spent in improving, building, etc., and large extensions in the line of buildings and area will be imperative in the near future if the herd is to maintain its present progress.

I am constantly receiving enquiries from foreign Governments and Administrations regarding stock. To enable such enquirers to see what herds are kept at Pusa and the average number available for disposal each year, I propose to have a permanent advertisement in the "Agricultural Journal of India" giving these facts and other particulars.

Sheep. The attenuated garrison which held the fort at Pusa for some fifteen years against every disease under the sun, marched out of Pusa on 7th April, 1919, thereby terminating an experiment which has conclusively shown that the local conditions militate far too strongly against any attempt to improve fleece and mutton conjointly, as the improved cross immediately becomes liable to numerous diseases which do not seem to affect the local sheep, and an appalling death rate is the result. I use the word improved cross advisedly—as from the mutton fleece point of view. The spirit was doubtless willing but the flesh was uncommonly weak and the majority were never in such good condition as the local sheep. I may here say that such an experiment as the above carried on in a restricted area occupied by a large herd of cattle is liable to, and has possibly brought in, much disease; and it was the strong suspicion that such was the case, coupled with the impossibility of finding area for both cattle and sheep, that was partly responsible for the abandonment of the sheep experiments.

Miscellaneous. Plans have been put up for increasing the present veterinary dispensary. Over 8,000 patients were dealt with last year, which is straining the capacity of the place to the utmost.

I wish here to express my thanks for the way in which the cattle staff have worked. The work under their charge

has increased enormously and the inoculation camp which is now an annual event has added a heavy burden. This has all been cheerfully borne and the work has been excellently done. The reputation the cattle here now enjoy is in no small measure due to this continuous work and care.

IV. Programme for 1919-20.

Major.

I. (*a*) Practical treatment of pedigree dairy herd of Indian cattle and pedigree dairy herd of Montgomery-Ayrshire cattle.

(*b*) Continuance of experiments with regard to fixing a type of Montgomery-Ayrshire cross most suitable to Indian conditions.

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 Pusa farm is used for the maintenance 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, seed and silage.
(*c*) Implements and machinery.
(*d*) Technique of cultural operations.
(*e*) Types of farm buildings.

III. Continuation of collection of data and results regarding the costs and capabilities of steam tackle on estates of this size.

IV. Experiments with various types of motor tractors and ploughs :—

(*i*) in comparison with steam tackle;
(*ii*) for collection of data and working costs;
(*iii*) for determination of most suitable type of tractors and implements for India—the co-opera-

tion of an agriculturist who is also an engineer is required here to enable these experiments to be thoroughly carried out;

(*iv*) collaboration with manufacturers regarding the manufacturing and introduction of any improvements in present types to suit Indian conditions.

V. *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 and wheat varieties.

(*c*) Manurial experiments, especially seasonal and quantitative tests with phosphates.

(*d*) Rotation and manurial experiments already started.

(*e*) Seasonal tests with Java and Sumatrana indigo.

(*f*) Trial of sugarcane varieties suitable for growth without irrigation. (Some of Dr. Barber's varieties are very promising.)

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

Minor.

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

REPORT OF THE IMPERIAL AGRICULTURAL CHEMIST.

(W. H. Harrison, D.Sc.)

I. Administration.

I availed myself of privilege leave from 4th July to 7th August, 1918, and during this period the First Assistant, Mr. J. N. Mukerji, was placed in charge of the Section. For the rest of the year I was in control.

Mr. J. Sen, Supernumerary Agricultural Chemist, continued on special duty under the Government of the United Provinces in connection with the opium investigations. His continued absence from his permanent post at Pusa entails considerable inconvenience to the head of the Section who, as a consequence, must necessarily give more attention to the routine analytical work than is desirable if material progress is to be made in research.

II. Education.

Mr. A. K. Mitra, who joined on 1st June, 1918, as a stipendiary student of the Bihar and Orissa Government, received tuition during the whole of the year under review.

III. Meeting of Agricultural Chemists.

The First Meeting of Agricultural Chemists was held at Pusa on 24th February, 1919, and the following days. The proceedings were opened by the Agricultural Adviser to the Government of India. The subjects placed for consideration before the meeting covered a wide field and comprised the drafting of a Fertilizer Act applicable to Indian conditions; the proposal of the Industrial Commission in regard to the formation of a chemists' service; standardization of analytical methods; the regulation of soil surveys and the necessity for the formation of groups of scientific officers for the specific study of specialized agricultural problems such as animal nutrition, soil biology,

etc. A report of the proceedings has been prepared for publication.

IV. Meteorology and drain-gauges.

The usual meteorological records were maintained, and in addition continuous records of the readings of wet and dry thermometers were instituted. The crops and drainage waters from the drain-gauges were examined in the usual manner.

V. General analytical work and assistance given to other sections.

The following samples were analysed and reported upon during the year :—

Soils	43
Manures	23
Feeding stuffs	13
Sugarcane	46
Gur (crude sugar)	1
Hide salt	3
Carbon bisulphide	3
Copper sulphate solution	17
Fungicides	2
Lead arsenate	1
Contents of stomach and intestines of a buffalo	1
Total	153

Among the items of interest in this connection, attention may be drawn to the number of feeding stuffs and fodders which were received for examination in relation to suspected cases of poisoning. In only one instance was the suspicion confirmed by analysis where a considerable proportion of prussic acid was obtained from a sample of linseed cake from a remount depôt. Acting upon the analytical report the use of this cake was discontinued when a complete cessation of the cases of poisoning occurred. The appearance of the cake suggested that it was the production of the ordinary country mill, and probably the expression of the

oil took place at a low temperature. The enzyme responsible for the liberation of the prussic acid from the cyanogenetic glucoside therefore remained undestroyed.

The following assistance was rendered to other Sections :—

Mycological Section. Seventeen samples of copper sulphate solutions were analysed in order to determine the loss of copper sulphate during the steeping of jute seed. Two samples of soils and three of fungicides were also examined.

Entomological Section. Twelve samples of soil and three of carbon bisulphide were reported upon.

Agricultural Section. Forty-one samples of sugarcane and thirteen manures were analysed.

Indigo Research Section. Six soils and four samples of manure were reported upon.

General. In compliance with the generally expressed wish of members of the Pusa staff the soils and subsoils of the permanent manurial experimental plots were carefully sampled and the variations in composition determined. These samples have not been included in the list given above.

VI. Methods of analysis.

The investigation upon the value of Dyer's method of estimating available phosphoric acid when applied to calcareous soils was referred to in last year's report, and the conclusions therein formulated have been confirmed. The problem of finding a suitable basis for the interpretation of the values obtained, or, alternatively, of evolving a new basis of comparison, has been merged in the wider investigation regarding the retention of phosphates in soils, and will be considered in that category.

Arising out of the recommendations of the Chemists' Meeting a critical study of the various methods of determining nitrogen in fertilizers has been undertaken.

VII. Mode of action of superphosphate in calcareous and non-calcareous soils.

In continuation of the investigation, reported last year, dealing with the reactions between mono- and di-calcic phosphates and calcium carbonate, attention has been directed to the retention of P_2O_5 in calcareous and non-calcareous soils, Pusa and Kalianpur soils being taken as the respective types. Formerly the phenomenon of retention by soils was explained as solely due to the formation of comparatively insoluble phosphates, but in later years the tendency has been to ascribe it largely to adsorption. In view of the facts that Pusa soil contains a very large proportion of $CaCO_3$, and that the mono- and di-calcic phosphates react with this substance, it seemed probable —even if the laws of adsorption were the determining factor in non-calcareous soils—that retention would be mainly due to chemical combinations in calcareous soils.

In order to test this, definite quantities of the type soils were shaken with a definite volume of solutions of superphosphate of varying concentrations, and the distribution of the P_2O_5 between the solvent and the soil determined. On plotting the logarithms of these values against each other it was found that, in the case of the non-calcareous soil, they lay upon a straight line, which is the criterion for adsorption. In the case of the calcareous soil the points lay along a sinuous curve; consequently adsorption is the determining factor in non-calcareous soils but not in calcareous soils.

A similar series of determinations with solutions of di- and tri-sodium phosphates showed that adsorption occurred in both calcareous and non-calcareous soils, and consequently the conclusion to be drawn is that the retention of superphosphate in the former type of soils is one of chemical combination.

A variation of these experiments was made by allowing one kilo of soil to remain in contact for one week, without shaking, with 450 c.c. of solutions of varying concentrations of superphosphate, and then determining the distribu-

tion of the P_2O_5 between the solvent and the soil. Under these conditions the results obtained with both types of soil were almost identical. This is explained by the fact that the Kalianpur soil contains a small proportion of $CaCO_3$ and as the proportion of soil taken was large there was sufficient $CaCO_3$ present to combine with the quantities of P_2O_5 taken. It may therefore be accepted that even small quantities of $CaCO_3$ can, under certain conditions, entirely mask retention through adsorption.

The conclusion arising out of these experiments is that the distribution, throughout the mass of the soil and immediate subsoil, of the P_2O_5 contained in a dressing of superphosphate applied to the type soils would be of a very different order in each case. To test this conclusion a definite amount of P_2O_5 dissolved in a known volume of water was allowed to percolate through a column of soil of 20″ depth contained in a glass tube. When percolation had ceased the tube of soil was cut into two inch sections and the amount of P_2O_5 retained in each section determined. An approximate determination of the P_2O_5 held in solution in each section and the P_2O_5 retained by the soil was also made.

In the case of the Kalianpur soil the percolate contained very appreciable quantities of P_2O_5, and the amount held by the soil varied from 12 per cent. of the original amount taken in the first layer of soil to $2\frac{1}{2}$ per cent. in the lowest. The total amount of P_2O_5 (soluble and in solution) retained by any one section was in accordance with conditions demanded by adsorption.

The distribution through the column of Pusa soil was totally distinct. No P_2O_5, or only traces, were obtained in the percolates, and 69 per cent. of the original amount taken was retained in an insoluble condition in the first two inches and 76 per cent. in the first four, whilst practically no P_2O_5 penetrated to a greater depth than 12 inches. It is also noteworthy that the amount of P_2O_5 present in solution in the Pusa soil was very much less than the amount present in the corresponding section of Kalianpur soil.

The addition of 5 per cent. $CaCO_3$ to the Kalianpur soil brought about a distribution analogous to that obtained in

the Pusa soil, thus demonstrating the fact that this substance is the responsible agent of retention in the latter.

The general conclusions arising out of this investigation are (*a*) that the retention of P_2O_5 in calcareous soils is a different phenomenon to that of non-calcareous soils, (*b*) that the range over which applications of superphosphate are effective is wide in the case of non-calcareous soils but very restricted in the case of calcareous soils, and (*c*) that the principles underlying the employment of superphosphate in non-calcareous soils or soils of low $CaCO_3$ content are not applicable to calcareous soils, and that the conditions for effective phosphatic manuring in the latter require further close study.

VIII. The windrowing of sugarcane.

An Assistant was deputed to work at the Tarnab Farm, North-West Frontier Province, from December, 1918, to March, 1919, and during this period made numerous tests in order to follow the course of the changes taking place in the cane.

The scheme of experiment was as follows :—The sugarcane area was divided into three portions, the first of which was sampled and analysed on 18th December, 1918, and immediately windrowed. The second portion was sampled, analysed and windrowed on January 10th, and the remainder on February 3rd. It was possible, therefore, to institute comparisons between canes windrowed early and late, and at the same time by drawing representative samples the character of the changes which occurred in the windrowed cane could be determined at any time.

A study of the analytical data obtained showed that the total solids, as measured by Brix, increase during the period of storage, so that the juice becomes more and more concentrated as time goes on. At the same time the percentage of both glucose and sucrose increases, so that the juice of a windrowed cane contains a larger proportion of these constituents than does the original cane. On the other hand, the glucose ratio widens, and there is also a slight

increase in the proportion of "solids not sugar," so that a falling off in the quality of the juice is to be expected. That this is so is shown by the change in the co-efficient of purity, but this is not so great as might be expected, and in fact, owing to the increased concentration of the juice the variations in the percentage of crystallizable sugar are practically nil. Consequently the process of windrowing does not lead to any appreciable decrease in the amount of sugar obtainable from equal weights of juice.

It does not follow from the above, however, that there is no loss of sucrose and sugar so far as the crop is concerned, and this point can only be determined by careful weighments of the samples drawn and of the juice expressed. Such measurements were taken at each stage and the weights of sucrose, glucose, etc., calculated to the basis of 1,000 lb. cane when windrowed. The results obtained were remarkably concordant.

The amount of sucrose present in the cane windrowed on December 18th increased rapidly up to January 1st, and then remained practically constant until the first week in February after which there is a rapid decrease. The cane windrowed on January 10th showed a similar increase at first and again deterioration set in after the first week of February, whereas the cane windrowed on February 3rd showed only a continuous decrease. Similar fluctuations occurred with the weight of cane, weight of juice expressed, and are particularly well brought out in the case of crystallizable sugar. The weight of glucose, on the other hand, tends to increase uniformly.

All these comparisons show that cane can be stored by windrowing for some time, but that after a certain time has elapsed deterioration sets in. The date at which this first occurs is the same whether the cane be windrowed late or early in the season, and consequently would appear to be determined by factors which are either of a biological nature connected with the cane or to a seasonal one which affects all canes in a similar degree. It may, however, be pointed out that canes windrowed in December, 1917, showed no sign of deterioration four months afterwards, which

supports the theory that the determining factor is a seasonal one. This factor is one not easy of determination unless observations are extended over a series of seasons, but a comparison of the weather records for Peshawar for the seasons of December to March, 1917-18 and 1918-19, shows that the average temperatures were somewhat higher in the earlier season than in the later, and this would appear to throw out of court any question of temperature as being the real determining cause, although this is probably an important secondary factor. One comparison, however, is very significant and that is the date on which heavy rainfall was first experienced. In 1918 no rain of any meaning fell until the first week in March, and the canes showed no deterioration up to that time. Analyses made later showed the cane to be inferior. During 1919 a heavy downfall occurred about the first of February followed several days later by another heavy fall, and it is remarkable that this period marks the point at which rapid deterioration sets in. Thus during both years a falling off in the quality of the cane was first noticed during the period immediately following heavy rainfall, and this may consequently be provisionally selected as the seasonal factor which determines the length of the period during which canes may be safely stored by windrowing.

IX. Paddy manurial experiments.

A reference was made in last year's report to certain preliminary manurial experiments with paddy which were instituted in order to determine whether or not they could be successfully carried out under Pusa conditions. No insuperable difficulties were experienced but, as the sequel showed, it was an unfortunate circumstance that long-date South Indian paddies were selected. The paddy grew in a satisfactory manner but, although planted very early in the year, no flowering occurred until the cold weather had well set in, and as a consequence the seed formation was exceedingly poor and of no practical value for purposes of comparison. The vegetative yields were, however, satisfactory and may be utilized for this purpose.

Another noticeable feature was the fact that in a few isolated pots (about 6 per cent. of the total) a very abnormal growth took place, varying from 200 to 500 per cent. increase over the check pots in their particular series. These abnormalities occurred in pots containing green manure only, as well as in pots to which only ammonium sulphate had been added, and as the analysis of the soil gave no clue it is difficult to ascribe the result to any particular cause. I believe that other officers of the department have had a similar experience.

Eliminating these abnormal pots a fair comparison can be drawn. The underlying object of the experiment was to test the conclusion previously arrived at that green manures in relation to paddy cultivation mainly act in an indirect manner, and that their maximum effect would be experienced when they are employed in conjunction with direct manures. Nitrogen in the form of ammonium sulphate was taken as the variable mineral manure, and it was added in such quantity that each series contained nitrogen at the rate of 0, 20, 40, 80 and 160 lb. per acre as the case might be. To half the pots green manure was added at the uniform rate of 10,000 lb. per acre, so that a comparison of the effect of this quantity used in conjunction with increasing amounts of nitrogen could be determined. The average results were as follows, the crop values being given in grammes :—

Mineral manure added (rate)	Paddy No. 91 Madras			Paddy No. 24 Madras		
	Yield with ammonium sulphate only	Yield with ammonium sulphate and green manure	Increase due to green manure	Yield with ammonium sulphate only	Yield with ammonium sulphate and green manure	Increase due to green manure
No nitrogen .	84·6	135·5	50·9	139·8	150·3	10·5
N at 20 lb. per acre	93·8	146·8	53·0	155·3	174·9	19·6
N at 40 lb. per acre	97·7	155·8	58·1	192·8	199·3	6·5
N at 80 lb. per acre	140·9	203·6	62·7	194·9	236·3	41·4
N at 160 lb. per acre .	183·6	243·6	60·0	224·5	313·5	89·1

As this is a preliminary experiment, and is now being repeated under more stringent conditions, it is only necessary to point out that the increment due to the green manure tends to increase as the cropping due to nitrogen alone increases, thus giving some confirmation to the conclusions deduced from previous investigations.

A series of experimental pots have been laid down with the object of determining the comparative values to be ascribed to the direct and indirect action of green manures.

X. Miscellaneous.

At my request, my First Assistant repeated the laboratory experiments on which a portion of Memoir, Vol. II, No. 3, Botanical Series, "Note on a toxic substance excreted by the roots of plants," was based, using an artificial nutrient solution in place of the well water used by the author. Briefly, the method of experiment was to grow a large number of wheat, *arhar* (*Cajanus indicus*) and gram seedlings in the solution for a certain period of time, and then to allow the solution to evaporate spontaneously to one-third of its original bulk. A "blank" concentrated solution was also prepared by the evaporation of a solution in which no seedlings had been grown. It was found that the seedlings grown in this concentrated solution thrive much better than those grown in the "blank," thus offering no support to the theory of toxic excretion.

Samples of tobacco from experimental plots receiving different manurial treatment were examined for total ash, potash, chlorine, amido-nitrogen and proteid content, and it was found that, with the exception of chlorine, these values bore no relation to the treatment received. Tested for their burning value by Toth's method it was observed that tobacco manured with saltpetre burnt well but quickly, that with superphosphate treatment was much inferior. A combination of these manures produced a tobacco which burnt fairly well and not too quickly.

XI. Programme of work for 1919-20.

Major subjects.

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

2. Pot-culture experiments with paddy to determine (*a*) the relationship between the rate of drainage and crop production, (*b*) the direct manurial value of the nitrogen in green manures, and (*c*) the value of green manures when used in conjunction with nitrogenous mineral manures other than nitrates.

3. The mode of action of phosphatic manures in calcareous and non-calcareous soils.

4. A laboratory study of the changes occurring in windrowed cane.

Minor subjects.

1. Checking the accuracy of certain methods of analysis in confirmation to the general scheme drawn up at the Meeting of Agricultural Chemists.

2. A study of the conditions governing the formation of black alkali in soils irrigated by calcareous water.

XII. Publication.

Harrison, W. H. . Report on Agricultural Chemistry, 1917-18, for the Board of Scientific Advice.

REPORT OF THE IMPERIAL ECONOMIC BOTANISTS.

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

I. Introduction.

The Imperial Economic Botanist held charge of the Section during the year ending June 30th, 1919, with the exception of six weeks from October 22nd, 1918, which were spent on privilege leave in India. During this period, the Second Assistant, Maulvi Abdur Rahman Khan, was in charge of current duties at Pusa.

The work of the staff continues to be satisfactory. The Second Assistant has made himself very useful in connection with the improvement of the Botanical Area and in the experimental work in Central India and at Pusa. Chowdhry Ram Dhan Singh, B.Sc., Third Assistant, has worked well at the experiments in progress on indigo. This Assistant, on the recommendation of the Section, has been granted by the Government of India a stipend of £150 a year for three years with a free passage both ways to enable him to read for an Honours degree in Natural Science at Cambridge University. Babu Kashi Ram, Fourth Assistant, continues to do useful work in connection with the vegetable-drying experiments at Quetta and with the tobacco-breeding experiments at Pusa.

The difficulties in connection with the transport of seed by rail, referred to in the last report, increased considerably during the year. In consequence of the control of wheat which was rendered necessary by the shortage of supplies in India, the facilities granted last year by the Central Transport and Foodstuffs Board lapsed when that body ceased to exist. The system of priority certificates in force worked fairly well till the end of April when all movement of goods had to be restricted due to the exigencies of the military situation on the North-West Frontier.

A consignment of 3,000 mds. of Pusa 4, purchased for the Gwalior State to replace the country crop at certain centres in the famine-stricken areas of the State, unfortunately was only partially cleared by the railway before all civil transport became impossible. A very favourable opportunity for starting a new centre of distribution on the large scale with this wheat could therefore not be fully utilized. As the wheat could not be stored it had to be sold for local consumption before the rains set in. As soon as the Section possesses greater facilities, such difficulties can be surmounted by the simple device of storage in bulk and by the accumulation of large reserves which can be released as occasion demands.

II. Wheat.

Seed distribution in India. In the previous report, a detailed account was given of the progress made and of the means adopted in the substitution of the country wheats by Pusa 12 and Pusa 4. This work is being vigorously prosecuted and many new centres of distribution, including the Chin Hills in Burma and many of the Indian States, have arisen in various parts of the country. As usual, the amount of botanically pure seed available for starting these centres proved inadequate and little or no restocking of old ones was possible during the year. The area under Pusa 12 and Pusa 4 during the season of 1918-19 was estimated at half a million acres. The increased value of the crop, judged by numerous crop-cutting experiments, is at least fifteen rupees an acre so that the annual dividend on this portion of the work of the Section has already reached seventy-five lakhs of rupees (£500,000 sterling) and is rapidly increasing. As one year is too short a period to justify the time and trouble to all concerned in preparing a fresh summary of the position of these seed distribution schemes, progress will be recorded in the next report and in future in alternate years. In the present paper, the space so saved will be devoted to an account of some other aspects of these wheat investigations which have now reached the stage when they can usefully be discussed.

One very interesting example of a Pusa 12 replacement scheme entirely by means of unofficial agency should, however, be mentioned. This is the seed distribution scheme in the Simla Hill tracts in which Mr. H. E. J. Peake, the proprietor of the Khaltoo Fruit Orchards, and Sardar Narain Singh, Chief Secretary of the Sirmoor State, have interested themselves. In spite of the drought which last season ruined many of the fields sown with the ordinary crop, Pusa 12 did well. The number of villages growing this wheat rose from three to eight and the area increased nearly sevenfold. From small beginnings, a large bulk of seed has now been obtained which will facilitate the extended operations in progress. The aim is to establish a large continuous block of this variety in Sirmoor.

Intensive wheat cultivation. As pointed out in the last report, the substitution of the country crop by an improved variety is only the first step in raising wheat production in India to a higher level. The increased yields so obtained and the higher price per maund realized for the produce, are important means of establishing confidence and of setting up harmonious working relations between the Agricultural Department and the cultivators. The work of systematic substitution corresponds therefore to the duties of the advance guard of an army. The next step is the demonstration of the extraordinary response of superior types like Pusa 12 and Pusa 4 to improved soil conditions. It is here that the Agricultural Department will encounter its greatest difficulties and where it will eventually achieve its most striking triumphs. Briefly stated, the problem is the removal, in advance, of the factors which now limit production. A beginning has already been made in the direction indicated and results are beginning to appear. At Shahjahanpur in the United Provinces, Clarke has obtained 36·5 maunds of Pusa 12 to the acre, after sugarcane, in a year which was not particularly favourable. At Indore, on the black soils of the Malwa plateau, Coventry has obtained, on a plot of Pusa 4, 1·36 acres in area, sown on December 15th, a yield of 35

maunds of grain to the acre. In Bihar, Justin Finch, on an area of over 10 bighas, has obtained, under estate conditions at Mangalgarh, the record yield of $40\frac{3}{4}$ maunds of Pusa 4 to the acre. These figures indicate the potentialities of the soils of India and what can be done by the simple process of raising the content of organic matter and of increasing the internal surface of the pore spaces on which the wheat roots feed.

Pusa wheat in other countries. In previous years, small samples of Pusa wheats have been sent by post to correspondents in various parts of the world either for use in plant-breeding investigations or for direct trial. In many cases these samples have been worked up into large stocks and the wheats are now coming into general cultivation. In New South Wales, Pusa wheats regularly take prizes at the Royal Agricultural Show at Sydney and last year figured in the official account of the exhibits of the Easter Show published in the *Agricultural Gazette of New South Wales* of August, 1918. In West Australia, Pusa 4 has yielded over 30 bushels to the acre under field conditions and is considered there to be a rust-proof variety. In Uganda, Pusa wheats have been acclimatized and are being distributed by the Agricultural Department chiefly to European planters. In South Africa, Pusa 4 and Pusa 12 find a place in the list of varieties cultivated in the Union which was recently drawn up by the Agricultural Department. In Nigeria, extensive trials of Pusa 12 and Pusa 4 are in progress in the highlands of Sokoto, Kano and Bornu. Several small samples have recently been asked for from Canada, the United States, Brazil, the highlands of Java and the Soudan.

Water saving in wheat growing. During the year, the investigations on the water requirements of the wheat crop which have been in progress since 1912 have been summed up in the new edition of Quetta Bulletin No. 4—*The saving*

of irrigation water in wheat growing—the first edition of which appeared at the end of 1915 and which has been out of print for some time. At first, these investigations were confined to the Quetta valley but during the last three years they have been extended to the important wheat growing tracts of North-West India. The results obtained are so definite and the direction in which wheat production in these areas can be improved is so clearly indicated, that it appears desirable to take this opportunity of summing up the present position of these investigations.

The Quetta experiments fall into two stages. It was first found that, on roughly levelled land, a crop of from 15 to 20 maunds of grain to the acre could be grown on one irrigation, applied before sowing, provided care was taken to obtain a good tilth and to break up rain crusts during the winter and spring by means of the lever harrow. This is considerably more than the yields obtained by the zamindars on similar land with six or seven irrigations. In the second stage, a further increase in the duty of water was secured. This was obtained by carefully grading the land[1] and by the employment of a leguminous rotation. In 1918-19, on land carefully graded and after a summer fallow preceded by a cold weather crop of clover, a yield of 32 mds. 27 seers (2,686 lb.) of grain and 57 mds. 13 seers (4,715 lb.) of straw was obtained on an acre plot on the preliminary watering only. The land was irrigated before sowing on October 12th and cultivated lightly with the spring tine cultivator followed by the beam on October 16th as soon as ever the surface was dry enough for this purpose. Under the thin mulch so produced, the soil dried slowly and yielded a perfect tilth when it was ploughed with iron ploughs on October 19th. Before ploughing, the

[1] The details relating to the method of levelling adopted and to the system of irrigation for alluvial soils worked out at Quetta are described in Quetta Bulletin No. 7—*The irrigation of alluvial soils*—published in 1916.

seed was scattered broadcast on the surface and after the whole area was ploughed once, the beam was run over the land both ways. Besides the saving in cattle power, this method of combined tilth production and seed covering, by means of the iron plough, involves the minimum loss of moisture. Afterwards, rain crusts were broken by the harrow seven times, the last operation taking place on April 15th, 1919. Side by side, about three acres of similar land which was only roughly levelled and which had not borne a clover crop were treated in the same way. The yield in this case was much lower—19 mds. 31 seers (1,625 lb.) of grain and 33 mds. 15 seers (2,745 lb.) of straw to the acre.

In 1916, a beginning was made in the application of the methods worked out at Quetta to the conditions of North-West India. The first results were obtained in 1917 on the estates of Rai Bahadur Ganga Ram, C.I.E., M.V.O., and Rai Bahadur Sewak Ram at Gangapur and Haripur in the Lyallpur District and at the seed farm at Sargodha in the Jhelum Colony. The preliminary irrigation gave nearly ten maunds of wheat to the acre, one additional watering after sowing yielded a little over sixteen while three irrigations reduced the yield appreciably. At Mirpurkhas in Sind, where the texture of the soil is finer than that of the Canal Colonies of the Punjab, Main[1] obtained still better results. After a deeply cultivated hot weather fallow and a double irrigation in the latter half of October, *pissi* wheat on stiff working soils gave over 19 mds. (1,533 lb.) to the acre. On similar land which received in addition one irrigation in January the yield was $23\frac{2}{3}$ mds. (1,894 lb.) per acre. Under the local Sindhi methods, four or more waterings would have been applied to the standing crop. Other comparative results obtained the same year in the manner described above are summarized in Table I.

[1] Main, T. F. *Agricultural Journal of India*, vol. XIII, 1918, p. 653.

TABLE I.

Water saving results obtained at Mirpurkhas, 1916-17.

Variety	Area in acres	Yield of grain in lb. per acre		Remarks
		One watering after sowing	No watering after sowing	
Pusa 12	The comparisons were made on half plots measuring 1 to 1½ acres per plot	1,333	1,172	Soil somewhat stiff.
Pissi		2,048	1,533	
Pusa 12		1,116	970	Light, free-working soil.
Pusa 12		1,600	1,680	
Pusa 12		1,418	2,062	
Pusa 12		1,718	1,633	
Pusa 12		1,067	1,333	
AVERAGE		1,471	1,483	

It will be seen that taking all the results in this table together, the extra watering, on the average, not only produced no result but slightly depressed the yield. Taking the results on the light, free-working soils only, the average yield on the preliminary watering comes to 1,535 lb. per acre while that with the extra January irrigation is only 1,383 lb. per acre. Thus on a soil with good texture, the second irrigation depressed the yield by no less than 152 lb. per acre.

The most striking results on water saving so far obtained in the plains of North-West India were secured by Clarke at the Sugar Experiment Station at Shahjahanpur in 1919 after the poor monsoon of 1918 (Plate V). The rainfall of June, July and August amounted to 21·9 inches and there was practically no rain during September and October. The wheat (Pusa 12) was sown on natural moisture in October and was irrigated once only in November. The cold weather rainfall was 2·63 inches all of which was received in January, 1919. The yields obtained

PUSA 12 GROWN WITH ONE WATERING AT SHAHJAHANPUR.
Area 3·4 acres—yield 36·5 maunds per acre.

PLATE V.

are given in Table II. The sample of grain was a very fine one with the uniform texture which millers so much appreciate.

TABLE II.

Yields obtained with Pusa 12 at Shahjahanpur with one irrigation, 1918-19.

Previous crop	Area in acres	Total yield of grain in maunds	Yield per acre in maunds
Sugarcane in trenches	3·4	124	36·5
Sugarcane mostly on the flat, a little in trenches	7·4	233	31·5
TOTAL	10·8	357	AVERAGE 33·1

Taking all these results together, two principles stand out clearly. In the first place, it is evident that a fair wheat crop in North-West India can be obtained under ordinary conditions and on ordinary land by means of the preliminary irrigation only. In the second place, if the texture of the soil has been improved and if the surface has been properly graded (as was the case in the Quetta and Shahjahanpur experiments of 1918-19) the duty of water is very greatly increased and extremely heavy crops are possible with a comparatively small volume of irrigation water. Further waterings in these two experiments would have produced no useful result as the grain in both cases was well filled and the yield had already reached the limits imposed by the standing power of the varieties grown. The establishment of these two principles leaves no doubt as to the main direction of improvement in wheat production in North-West India. A portion of the wheat and gram grown should be raised on the preliminary irrigation only supplemented by the winter rains or at the most by one additional watering. The water thus set free should be used for the production of leguminous fodder

crops like lucerne, *senji* (*Melilotus indica*), berseem and *shaftal* (*Trifolium resupinatum*). Most of these can be made into excellent hay and can be baled, either separately or mixed with an equal amount of *bhusa*, for transport purposes. For some years past, trials of these fodders have been carried out in the Fourth Division at Quetta, the results of which prove that by their use the weight of animal food carried by an Army on active service can be reduced by at least one-third with some reduction in cost. Similar advantages would be obtained in ordinary road transport. The general improvement in the organization of the local fodder supplies would go far to solve the cattle and milk problems and would also increase the supply of manure. A large nucleus of dried leguminous fodder in North-West India would also be an advantage in time of famine when one of the problems is to rail into the affected areas sufficient forage to save the lives of the cattle. These leguminous fodders give the best yield if the land is well manured. If, therefore, the zamindar were to put up to a fifth of his land into these fodders every year and were to concentrate his supply of manure on this area, this valuable rotation would rapidly improve the texture of the soil. This in turn would increase the yield of wheat and would also raise the duty of water. A great impetus will be given to this work when the Army take up leguminous fodders for transport work on similar lines to those recently adopted in Egypt where about 150,000 tons of berseem hay were baled for the use of the Armies of Palestine and Salonika.

The breeding of rust-resistant varieties. An important stage in the breeding of rust-resistant wheats for India has been reached. This work was started in 1910 at Cambridge where a number of Indian pure lines were sown as spring wheats and crossed with some of Professor Biffen's new rust-resistant hybrids. From the crosses so obtained many new forms have been fixed at Pusa which are characterized by strong straw, rust resistance, good standing power and heavy yield. These are now being tested on a

field scale and are yielding very promising results. Unfortunately some of the Pusa 6 crosses have inherited one defect, namely, their inability to hold their grain for a long period in a dry season. To remove this they have been re-crossed with short-strawed, rust-resistant Indian types of high grain quality which hold their grain well. From the crosses so obtained it is expected that ideal types suitable for the damper wheat-growing areas of India will be obtained. It must be remembered that rust-resistance by itself is of little economic value. It is only when this character is combined with a large number of others that it becomes of use to the country. If the wheat rust problem, as is sometimes thought, consisted only in the isolation of rust-resistant types this portion of the wheat investigations at Pusa would long since have been completed. The problem before the plant breeder, however, is much more difficult than this.

Trials of new Pusa wheats. The trials, on a field scale, of some of the new series of Pusa wheats which were begun in 1917-18 have been continued during the last year. Those at Kalianpur and Cawnpore were carried out by Mr. B. C. Burt while the Pusa tests were made in the Botanical Area. The results are given in Table III.

TABLE III.

Trials of new Pusa wheats at Pusa, Cawnpore and Kalianpur, 1918-19.

Variety	Pusa	Cawnpore	Kalianpur	REMARKS
Pusa 12 . . .	—	2,230	2,143	In all cases yields are expres-ed in lb. per acre.
Pusa 31 . . .	1,974	1,910	1,708	
Pusa 36 . . .	2,139	1,940	2,061	
Pusa 37 . . .	2,221	2,020	2,009	
Pusa 43 . . .	2,496	2,150	2,170	

Trials of new Pusa wheats at Pusa, Cawnpore and Kalianpur, 1918-19—contd.

Variety	Pusa	Cawnpore	Kalianpur	Remarks
Pusa 44 . . .	2,496	2,210	2,072	
Pusa 45 . . .	2,433	2,280	2,001	
Pusa 4	2,102	2,130	2,168	
Cawnpore 13 . . .	—	—	1,668	

The trials are being repeated as the season of 1918-19 in the *Doab* was abnormal. The monsoon was a failure at Cawnpore while hot winds during the ripening period lowered the yield of the later kinds very considerably.

III. Indigo.

In last year's report, a somewhat detailed account was given of the work in progress on Java indigo. This dealt with a study of the conditions necessary for growth and for seed formation, of the factors of importance in root development and of the principles underlying improvement by selection. These investigations are being continued and extended. During the past year, a number of interesting results have been obtained many of which bear on the practical aspects of the industry.

Indigo wilt. One of the difficulties encountered in the cultivation of Java indigo in Bihar is a condition known as wilt. After the middle of the monsoon, it often happens that the Java plant ceases to thrive, growth slows down, the foliage changes colour and afterwards becomes progressively reduced in amount. This is followed by the gradual death of the plant. Associated with the wilted condition during this period is extensive destruction of the fine roots and nodules. As there appeared to be a connection between the rise of the subsoil water in Bihar (Plate VI) and the development of wilt, a series of lysimeter experiments was carried out in 1918 in order to determine whether or not there is any relation between waterlogging

from below and the appearance of this trouble. The lysimeters consisted of cemented tanks, $\frac{1}{1000}$ of an acre in area, built above the ground level and provided with drainage openings which could be closed or opened at will. Two series of three lysimeters were constructed. One set was filled with soil from the Kalianpur farm near Cawnpore, the other with light Pusa soil. The Kalianpur soil is exceedingly rich in available phosphate (0·318 per cent.) while Pusa soil, when analysed by Dyer's method, gives very low figures for available phosphate (0·001 per cent.). The results obtained were as follows :—

(1) In both Pusa and Kalianpur soil, the indigo in the lysimeters with free drainage escaped wilt.

(2) When the drainage openings were closed and waterlogging from below took place, all the plants were wilted in both Kalianpur and Pusa soil.

(3) The wilt in the Kalianpur soil (rich in available phosphate) was much more pronounced than in Pusa soil (said to be low in available phosphate).

(4) The growth in Kalianpur soil was much slower than in Pusa soil.

(5) The stoppage of drainage brought about an interesting change in the root system of the indigo and caused the laterals to run near the surface.

Root development. The systematic examination of the root system of this crop throughout the year, in various soils and under different conditions of growth, continues to yield interesting results. This work is still in progress and is not likely to be completed for some time. The effect of previous waterlogging on stiff soil on the root system is very marked. Five months after sowing, equal areas on the the waterlogged and control plots were taken and the heights of the plants were measured. On the waterlogged plot, the average height of 200 plants was 10·4 cm., on the control the average height of an equal number of plants was 28·0 cm. When the root system of the plants on these plots was examined, it was found that the first effect of

waterlogging was to restrict the roots to the upper layers during the first few months of growth and to change the general character of the root system. The development of the tap root is soon arrested and later in the season one of the laterals after bending takes its place. When the subsoil is more porous, the effect of waterlogging before sowing is less.

Selection. An important discovery has been made and utilized in the selection work in progress on Java indigo. Some time ago it was observed that if any set of August sown seed plants is cut back during the early hot weather, there is a great range in the capacity of the individuals to form new growth. There is every gradation between abundant and rapid new growth and the development of weak wilted branches.

Seed production. For the fifth year in succession, the continuous Java indigo plot in the Botanical Area yielded a fine crop of seed in spite of an unfavourable season due to the heavy rains in August just after sowing and to the early cessation of the monsoon in September. This plot has never received any artificial manure nevertheless the seed crop continues progressively to improve. A good crop was also obtained on a field lent by the Dholi Estate. In this case also no artificials were applied to the land and the present is the third crop of indigo seed which has been raised during the last three years.

In connection with these field results, the effect, on the growth and seed formation in this crop, of alterations in the soil texture was investigated by the modified system of pot culture described in a paper read at the Indian Science Congress at Lahore.[1] In this method, the soil conditions down to a depth of two feet can be altered by the addition of such aerating materials as sand, broken tiles and leaf mould or a combination of these substances. The effect on the growth and seed formation is given in Table IV where the results are expressed in grammes in terms of 50 plants.

[1] *Agricultural Journal of India*, Special Indian Science Congress Number, 1918, p. 36.

TABLE IV.

The effect of altered soil texture on growth and seed formation in Java indigo.

Soil treatment	Weight of dry stems (excluding leaves)	Weight of dry seed
1. Control (soil disturbed)	68	32
2. Soil 1/2 +sand 1/2	127	70
3. Soil 9/10+ potsherds 1/10	118	92
4. Soil 8/10 + potsherds 2/10 . . .	141	94
5. Soil 7/10 + potsherds 3/10 . . .	136	89
6. Soil 4/10 +potsherds 3/10 +leafmould 3/10.	744	511
7. Soil 7/10 +leafmould 3/10	907	577
8. Soil 5/10 + postsherds 2/10 + leafmould 3/10.	905	595
9. Soil 6/10 + potsherds 1/10 + leafmould 3/10	715	685
10. Control (soil disturbed)	72	32

An inspection of the table shows that while the substitution of ten to thirty per cent. of the soil by potsherds multiplies the yield of seed three times, the effect of leafmould with or without potsherds was much greater. Thus the substitution of forty per cent. of the volume of the soil by leafmould (30 per cent.) and potsherds (10 per cent.) increased the production of seed twenty-one times. Another interesting feature was the cessation of growth in length in all cases at the beginning of December quite independently of the soil conditions or of the size of the plants. This always occurs under field conditions. For large yields of seed, large plants must be produced by the beginning of December and practically all the seeds must have set by this time. Bearing in mind the small amount of growth which is possible up to the beginning of October, it is evident how rapid the development must be during October and November if crops of seed over ten maunds to the acre are contemplated.

The growth of indigo. A large amount of careful experimental work has been carried out on the conditions necessary for the establishment of the ordinary crop. Sowing should be done early—if possible before the *hathia* in the beginning of October—and the land should be clean fallowed and well cultivated beforehand. Later sowings are nothing like so successful. As regards the soil conditions necessary, the addition of moderate dressings of organic matter, applied in the hot weather or on the early rains, greatly assists in the establishment of the seedlings and in the early growth of the crop. If sown on very poor land, it has always been observed that Java indigo establishes with great difficulty and that numerous blank spaces occur. These results indicate the need of combined nitrogen for the early growth of this leguminous crop. This was confirmed by the behaviour of indigo on plots uniformly manured with 15 maunds of oilcake to the acre, a portion of which was waterlogged for a month before the crop was sown. It is known from previous experience of the Pusa soil that waterlogging for a month during the late monsoon is sufficient to bring about extensive losses of combined nitrogen through denitrification. On the waterlogged portion of the plot, the indigo grew with great slowness at the beginning compared with the control and this difference has always been maintained through the hot weather. Thus the field results as well as those secured by the modified system of pot culture, all point to the need of combined nitrogen in establishing a good stand of Java indigo. On the other hand, it is well known that heavy dressings of substances like *seeth*, oilcake, and farmyard manure stimulate vegetative growth at the expense of indican formation, a process which takes place best if the plant is grown on land somewhat on the poor side. An interesting field of investigation is therefore indicated. It may be found to pay to stimulate the crop a little by means of organic matter so as to establish it rapidly and strongly even if the yield of indican per 100 maunds of green plant is thereby slightly reduced. The increased produce of indigo per acre might

be found to pay. Such a matter however cannot be settled by experiments on small plots on account of the well known difficulty in Bihar of obtaining even land to the depth made use of by this crop, and of manufacturing small lots of green plant. It is a matter which will have to be decided by general experience of work under estate conditions. Possibly the easiest and most economical method of testing the point would be to manure for the previous crop and to raise the indigo on land in fair condition.

IV. Drainage and crop production.

In the report of 1917-18, the bearing of the soil aeration factor on flood irrigation, as practised by the cultivators in North-West India, was discussed. It was shown that successful irrigation involves more than the mere application of water and that the aim of the irrigator should be *the provision of water in such a manner as to interfere as little as possible with the aeration of the soil.* At the meeting of the Indian Science Congress at Bombay early this year, another aspect of soil aeration was dealt with, namely, inadequate drainage—a matter of particular importance in many parts of India. Over large areas nourished by the monsoon this factor bars progress. Its removal, however, is a matter which often lies outside the scope of the Agricultural Department and its mere consideration involves a multitude of other interests—those of the cultivator, the landowner, the revenue authorities, the engineer and the sanitarian.

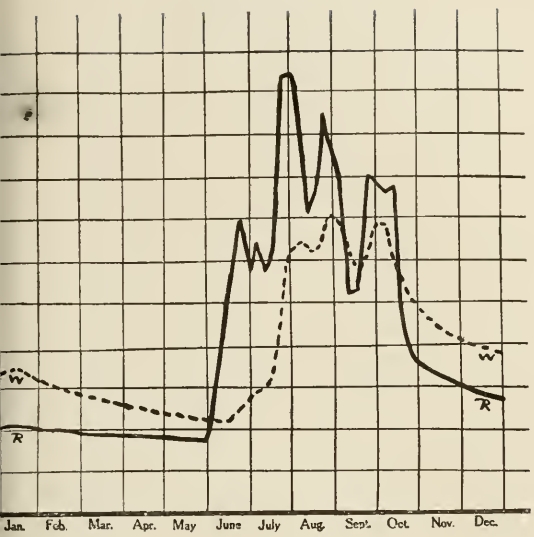
In the plains of India, defective drainage arises during the monsoon from two distinct causes. In the first place, when the soils are on the stiff side, local accumulations of rain water rapidly lower the fertility. In the second place, the subsoil water often rises to such an extent at a time when the flow of the rivers is impeded that little or no general drainage is possible over large tracts of the alluvium.

Surface waterlogging has been found to affect growth in two ways—by the destruction of available nitrates and

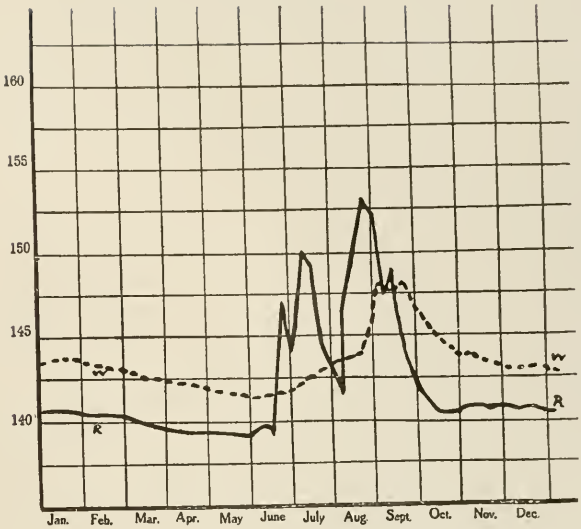
by a profound alteration in the physical texture of the soil. When the land dries after a long period of surface water-logging, it is difficult to obtain the ideal crumb structure and to provide sufficient room in the soil for root development. The clods do not readily break down under the beam and the soil is gummy to the feel. Colloidal substances appear to be formed under these anaerobic conditions which not only hinder the formation of a good tilth but also prevent percolation. It is quite common at Pusa after a very heavy monsoon to find the pore-spaces near the surface almost entirely filled with water for some considerable time after the level of the rivers and of the ground water has begun to fall. The surface soil does not seem to be able to drain. An improvement in the texture follows if the surface drainage is improved and in cases where organic matter has recently been added to the soil. The gummy substances do not then seem to be formed to any great extent and the clods readily break down. These matters require exact and careful investigation and it is difficult to suggest a more promising field of work for the soil physicist in India.

The effect of the rise of the subsoil water in preventing drainage is well marked in North Bihar after the monsoon has set in. The flow of the local rivers is soon checked by the rise of the level of the Ganges. As a result, the rivers overflow and the low-lying areas go under water. The rise in the level of the rivers is followed by a rise in the water-level of the wells. These movements of the river-level and of the general ground-water are illustrated in the curves opposite (Plate VI) which represent the condition of the river at Pusa and of one of the wells (about a quarter of a mile distant from the river bank) for the years 1910, 1912, 1913 and 1914. It will be seen that the curves of the ground-water level vary according to the year. In some years like 1912 and 1914, the curve is even and no great oscillations of level occur. In others, such as 1910 and 1913, there are well-marked oscillations. These oscillations, from the plant's point of view, are of the greatest

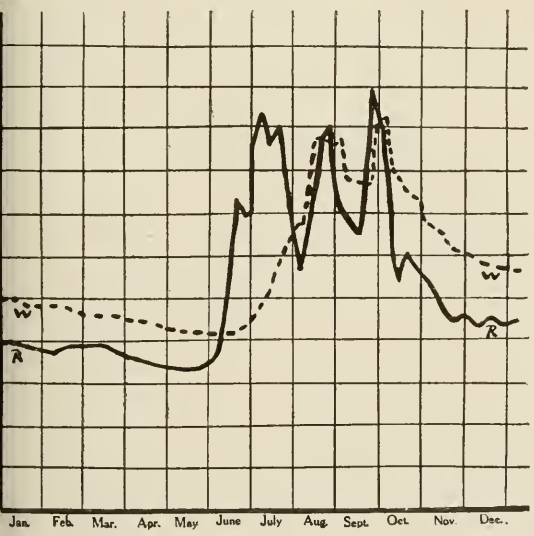
1910



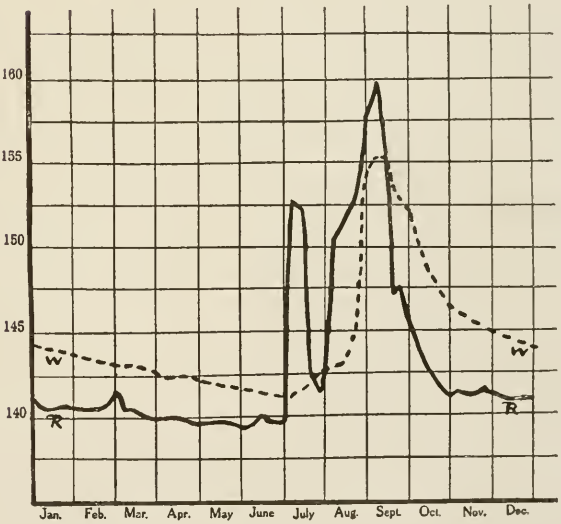
1912



1913



1914



CHANGES IN THE RIVER AND WELL LEVELS AT PUSA.

The well levels are shown by dotted lines
The observations are expressed in feet
above mean sea level.

importance as a fall in the level of the ground-water means a strong downward pull and the temporary resumption of drainage and of soil-aeration. In interpreting field experiments therefore in the monsoon, the amount of drainage which is possible may easily prove to be an important factor.

The effect of improved surface drainage on crop production has been found to be very considerable in the Botanical Area at Pusa. Not only is the loss of nitrates by denitrification greatly reduced but good drainage, combined with the checking of erosion, has had the effect of maintaining the fertility with a comparatively small expenditure of organic manure. The behaviour of two typical plots in the Botanical Area brings out this point clearly. In the case of plot 10, one and three-quarter acres in area, a typical wheat soil of rather heavy texture, the records show that during the last 15 years this field has produced 13 heavy cereal and 2 good pulse crops while the manurial treatment has consisted only of three green manurings with *sanai* (*Crotalaria juncea*) and a single dressing of castor cake at the rate of 15 mds. per acre. The present condition of the land shows that it has improved under the treatment. In 1919, yields of over 30 mds. of wheat to the acre were produced in a season which did not favour heavy crops. Another plot, No. 1, of somewhat lighter land and about one acre in area, has given, since 1905, 10 good crops of cereals, three of pulses and two of indigo seed. The manuring for these 15 heavy crops consisted of three green manurings, a total of 15 tons of farmyard manure per acre and a single dressing of 10 maunds of oilcake to the acre. The wheat crop of the last year was over 29 mds. per acre, the highest so far given by the area. Here again the land has increased rather than decreased in fertility. Similar experience has been obtained at Quetta where an area of land about 3 acres in area has been continuously cropped with wheat without manure since 1912. The wheat is raised on a single irrigation applied before sowing and

after the crop is reaped, care is taken to plough up the stubbles and to expose the soil to the sun and air during the summer months. The yield in 1919 was just under 20 mds. per acre, the highest so far obtained. Results such as those quoted above indicate that alluvial soils, if properly managed, do not require large quantities of organic matter to keep up their fertility. That such yields can be obtained at all indicates that nitrogen fixation in these soils must be much greater than is commonly supposed. The results obtained in the Botanical Area at Pusa and on the seed farms in the United Provinces clearly indicate that any fears of soil depletion in the plains of India are groundless. Increased rather than decreased yields are to be expected as surface drainage is improved, as erosion becomes checked, as the texture of the land is improved by the extended use of suitable leguminous rotations and as the conditions necessary for nitrogen fixation are elucidated and applied.

V. The sun-drying of vegetables.

The work in progress at Quetta on the sun-drying of vegetables has been extended considerably. Towards the end of last year (1918) this product was placed on the market for the first time at Quetta and also at Calcutta. About 1,500 half-pound tins were prepared which found a ready sale. The demand at Quetta was extraordinary. The orders amounted to about 20,000 tins of which only about five per cent. could be met. The principal purchasers were the engineering parties engaged on the Nushki Extension Railway and the various regiments operating in Mesopotamia and Persia.

An exhibit of Quetta sun-dried vegetables was arranged at the Medical Conversazione at Parel held in connection with the Bombay meeting of the Indian Science Congress. As usual, this attracted the attention of a large number of visitors. It also led to the establishment of an agency in Bombay for the sale of the product. The exhibit was afterwards shown at the Lucknow Flower Show.

During the present year (1919), the production of sun-dried vegetables at Quetta has been increased and seven selling agencies in India, in addition to the one at Quetta, have been stocked. The cost of production has been considerably reduced and the work accelerated by the use of power peeling and slicing machines imported from England. These have proved very successful and easy to operate.

The preliminary results obtained on the anti-scorbutic and anti-beri beri properties of sun-dried vegetables were communicated by Captain Shorten, I.M.S., Professor of Physiology, Medical College, Calcutta, to the Medical Section of the Indian Science Congress at Bombay. This aspect of the work has since been considerably developed and it is expected that the experiments will be completed during the present year.

VI. Fruit packing.

The sale of improved fruit boxes to the trade at Quetta continues to be satisfactory in spite of the delays on the railways resulting from the military situation on the Frontier in 1918 and 1919. It was expected that this cause would be sufficient to put an end to the business for the time being but the demand continues to increase and the boxes are sold off as fast as they can be prepared. One encouraging feature is the increasing tendency on the part of the dealers to purchase the well made strong crates holding 24 punnets which are now returned free of charge from all stations in India to Quetta and Chaman and which can be used many times. These are sold for Rs. 5-8 each and are taken up readily. It is quite safe to say that seven years ago when this work was started, not a single returnable crate would have been bought by the dealers. They have since found by experience, however, that it pays to put money into better packing and to adopt a system by which damage in transit is reduced to a minimum.

VII. Tobacco, fibres and gram.

Tobacco. The demand for seed of Type 28 continues to increase both for general cultivation and for cigarette purposes. Indents for about 5,000 acres of new cultivation were dealt with which has exhausted the whole of the supply of seed. A number of late indents have been transferred to 1920. An effort will be made this year to grow a larger stock of selected seed. In addition to applications for seed, a number of correspondents have asked for samples of cured leaf. It was impossible to supply any of these as all the land available was used for producing seed.

Fibres. In addition to its suitability for India, the improved type of *patwa* (*Hibiscus cannabinus* L.) known as Type 3, is doing well in other countries. After the preliminary trials, the Agricultural Department of the Union of South Africa cabled for five tons of seed of this variety. Only a hundred pounds could be spared and so the opportunity for introducing this type on a large scale into South Africa was lost.

Gram. A comparative trial at Pusa of some of the more promising types of gram gave the following results :—

	Mds.	Seers	
Type 17	29	32	per acre.
Type 18	27	37	,, ,,
Type 6	27	22	,, ,,
Type 23	26	25	,, ,,
Type 25	25	15	,, ,,

A considerable demand for seed of some of these types has arisen, a small portion only of which could be satisfied.

VIII. The pollination of Indian crops.

A further paper dealing with the pollination of Indian crops was prepared for publication during the year. In this the following crops were considered—San hemp (*Crotalaria juncea* L.), pigeon pea (*Cajanus indicus* L.), Java indigo (*Indigofera arrecta* Hochst.), Sumatrana indigo (*Indigofera Sumatrana* Gaertn.), linseed (*Linum*

usitatissimum L.), *taramira* or *duan* (*Eruca sativa* L.), *til* (*Sesamum indicum* L.) *niger* (*Guizotia abyssinica* Cass.), jute (*Corchorus capsularis* L. & *C. olitorius* L.) and roselle (*Hibiscus Sabdariffa* L.).

In the case of the leguminous crops studied—san hemp, pigeon pea, Java and Sumatrana indigo—it was found that methods of pure line selection based on the isolation of single plants are not likely to lead to any improvement. In these plants, methods of mass selection, in which crossing is permitted within certain limits, are likely to be considerably more successful.

In Indian linseed, natural crossing was found to be greater than was expected from a study of previous observations and of the mechanism of the flower. In critical work on this crop, it will be necessary to raise all seed under net.

IX. Programme and publications.

Programme, 1919-20. Investigations will be continued on the following crops on the lines indicated in the annual reports and in the publications of the Section—wheat, tobacco, fibre plants, indigo, gram, oil seeds, fodder crops and fruit.

Publications. Thirteen papers were written during the year of which the following have already appeared :—

1. Improvements in the Packing and Transport of Fruit in India. *Bulletin 2, Fruit Experiment Station, Quetta.* Third Edition, 1919.
2. The saving of irrigation water in wheat growing. *Bulletin 4, Fruit Experiment Station, Quetta.* Second Edition, 1919.
3. Report for 1917-18 on Economic Botany for the Board of Scientific Advice.
4. Drainage and crop production in India. *Agricultural Journal of India,* Special Indian Science Congress Number, 1919, p. 377.
5. The agricultural development of Baluchistan. *Bulletin 11, Fruit Experiment Station, Quetta,* 1919.

REPORT OF THE IMPERIAL MYCOLOGIST.

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

I. Charge and Establishment.

I held charge of the Section until 8th July, when I proceeded to the Federated Malay States on deputation to advise on some matters connected with the local Agricultural Department. Dr. Shaw, Second Imperial Mycologist, officiated for me until my return to India on 14th November. During this period Mr. Dastur, First Assistant, officiated as Second Imperial Mycologist.

I was appointed Joint Director of the Agricultural Research Institute, Pusa, in addition to my own duties, with effect from 20th January. Mr. Dastur was promoted to the Imperial Service and appointed Supernumerary Mycologist on 30th June, 1919.

II. Training.

Mr. M. Mitra, M.Sc., did a short period of research work, as a private student, up to 28th August, 1918, and again joined for a complete course on 27th May, 1919. Pandit S. D. Joshi, B.Sc., a private student, is taking the full course from 12th June, 1919.

III. Mycological Conference.

The second conference of mycological workers in India was held last February, and was constituted, under the orders of the Government of India, as a sectional meeting of the Board of Agriculture. Under these orders, which were issued as a result of the discussions at the Board of Agriculture meeting at Poona in 1917, it is intended to hold similar meetings biennially in those years in which the biennial meetings of the full Board do not take place. The meeting was attended by practically all the mycologists in India and lasted four days. A separate report of the proceedings has been issued.

IV. Diseases of plants.

(1) Ufra of rice. An account of the investigations on this disease carried out since the Bulletin published in 1913 was issued as a Memoir early in 1919. This contains a further study of the life-history and activities of the rice worm, *Tylenchus angustus*; an attempt to explain the anomalies in the behaviour of different classes of cultivated paddies to the disease, which were noticed in the earlier paper but which remained a complete puzzle until the close relation between atmospheric humidity and the movements of the worm on a dry surface was discovered; and finally the application of the facts ascertained to the control of the disease. Further work is in progress or contemplated regarding the factors which influence the motility of the worm and those which influence its persistence under field conditions from one season to the next.

(2) Black Band disease of jute. The research work on this disease was continued by Dr. Shaw during the year under review. The amount of disease in the Bihar jute crop was considerably less in 1918 than in the previous year. This was very possibly due to the earlier termination of the monsoon, and the consequent exceptional dryness during September, resulting in the jute seed crop being harvested a month earlier than in 1917. On the Pusa Farm, while the incidence of the disease was slight in the main area of the crop, one small field was very badly infected. This particular area had been under jute in 1916. Whether the intensity of the disease in a crop is in any way bound up with the length of rotation practised is a factor which must be considered in future field experiments. The fact, mentioned in the last report, that the late sown crop appears to be relatively immune was abundantly confirmed from the inspection of the jute crop all over Bihar. Statistics obtained from the diseased portion of the crop on Pusa Farm showed that it is only stems of a certain size and maturity which are liable to infection under natural conditions in the field. Thus of stems over 5 feet high about 20-25 per cent. were infected with *Diplodia*

Corchori, and the same proportion of diseased plants was observed on counting only stems which were 1 inch or more in thickness at the ground level. In any jute crop, however, there is a considerable number of plants which are the result of late germination and in which the stems remain thin and relatively short. Among stems of this size the disease was practically non-existent, and if such plants are included in the estimation the proportion of diseased stems may be as low as 3 per cent. The proportion of diseased stems among the larger plants, however, gives a more accurate measure of the extent of damage to the crop.

In Eastern Bengal, in August and September, 1918, the fungus was found present in Dacca, Mymensingh, Sinjhani and Haldibari. The number of diseased stems was very small, however, and unless the disease appears earlier it is evidently not likely to be a serious source of damage to the fibre crop. An interesting fact observed was that, in Dacca, red-stemmed varieties of *Corchorus capsularis* seemed to be less susceptible to attack than green-stemmed. On the Rajshahi Farm the crop was *C. olitorius*, both red and green-stemmed varieties, and in this crop also the disease was practically absent. Inoculations now in progress do not, however, support the idea that red-stemmed forms are absolutely immune. A number of artificial infections on the variety "kakya bombai" were carried out in the field, and of inoculations upon wounded stems 90 per cent. proved fatal and upon uninjured stems 50-60 per cent. resulted in the death of the plant. The success or failure of an infection upon an uninjured stem is probably very closely related to the conditions of temperature and humidity at the time and an endeavour will be made to elucidate the relative importance of these factors in the success of an inoculation. Microscopic examination shows that the hyphæ are capable of penetrating the epidermis directly and set up a rapid rot and disintegration in the cortex. This suggests the presence of a cytolytic enzyme, and indeed the fungus has been cultivated successfully on pure cellulose in a solution of inorganic salts.

During the season 1918 a series of field experiments was carried out with the object of throwing some light on the condition affecting the spread of the disease. The results were not so definite as was hoped, the experiments suffering considerably from the abnormal monsoon of 1918, but suggested that the spread of the disease through spores mingled with the seed was not an important means of dissemination. In this case it may not be necessary to persist in the steeping of the Bihar seed crop in a disinfectant. As a precautionary measure, however, the treatment with copper sulphate was carried out this year with some 40 tons of seed grown in Bihar.

While working on the black band disease of jute, a number of cases of disease due to infection with the sclerotial fungus previously identified as *Rhizoctonia Solani* Kühn were met with. It is by no means uncommon in the field for both this fungus and *D. Corchori* Syd. to occur on the same plant, and at first the natural tendency was to assume that all the pycnidia which were so frequently found associated with the sclerotial fungus were immature pycnidia of *D. Corchori.* In 1917 some jute plants were infected with pure cultures of *R. Solani* and all the plants became diseased and died. Upon the diseased portion of the stem small black pycnidia appeared. As these infections were carried out on plants in a field in which *D. Corchori* was rampant, it was thought that we had here a case of a natural infection with *D. Corchori* superimposed upon the artificial inoculation; a brief microscopic examination showing a condition which was considered to be immature *D. Corchori.* In 1918 observations at Dacca showed some cases of disease due to *R. Solani* in which the infection had obviously commenced at a point 2-3 feet above the ground level, and at the time it was by no means plain how a fungus which was only known in a sclerotial form succeeded in establishing itself in this way. Moreover, these specimens and other similar cases in the Pusa crop also showed a pycnidium on the outer surface. These pycnidia and those occurring on the infections of 1917

were now subjected to a more critical examination. The field specimens from Dacca and Pusa both agreed with the infected stems of 1917 in the character of the pycnidium and spores which it contained. While this resembled an immature stage of *D. Corchori* very closely it was obvious that, in the case of the 1917 infections, since they were at the time of this later examination nearly a year old, if the pycnidia were those of *D. Corchori* they should contain mature bicellular spores. In all cases, however, the spores were hyaline, oval and unicellular, and the possibility that this pycnidium was not an immature condition of *D. Corchori* but was a separate fungus, perhaps a stage in the life-history of the sclerotial fungus, had to be investigated. Measurements showed that the spores from the infected stem of 1917 were $16\mu-33\mu \times 5\mu-9\mu$. In the case of specimens collected in the field in Pusa the measurements were $16\mu-25\mu \times 7\mu-9\mu$, and in specimens from Dacca $20\mu-28\mu \times 7\mu-10\mu$. The spores of *Diplodia Corchori* average $24\mu \times 12\mu$, between the limits $20\mu-29\mu \times 10\mu-15\mu$; while therefore the spores of *D. Corchori* are twice as long as broad, those of the new pycnidium are about the same length but narrower. This distinction is not sufficiently marked to enable these spores to be readily distinguished from those of an immature pycnidium of *D. Corchori*, but since the former never become dark coloured or bicellular they can easily be distinguished, provided the age of the infection from which they are taken is known.

The question whether this new pycnidium was a stage in the life-history of the sclerotial fungus, identified in previous communications as *R. Solani*, could only be settled by culture work. Since this work is in progress at the time of writing, it is possible that the conclusions put forward here may be modified in the light of subsequent knowledge. Infections were carried out with a pure culture of the sclerotial fungus, isolated in Dacca, on four jute plants in Pusa. All these plants developed sclerotia and also pycnidia, containing spores measuring $16-24\mu \times 7-9\mu$. Cultures were obtained on agar from single spores and from

single sclerotia, and in both cases produced the sclerotial fungus (*R. Solani*) exactly as the original inoculum. Diseased plants from Dacca were found to carry both *R. Solani* and a pycnidium containing spores $20-28\mu \times 7-10\mu$. Cultures from single spores and single sclerotia from these specimens both gave the sclerotial fungus. The suggestion, therefore, is that the pycnidium is a spore-bearing stage of the sclerotial fungus, and that this pycnidium only occurs on the jute plant, the sterile form occurring in culture.

In April, 1919, a reference was noticed, in a current mycological journal, to a fungus parasitic upon jute in Formosa. The fungus was named *Macrophoma Corchori* Sawada sp. nov., and from the description appeared to be identical with the pycnidium described above. By the courtesy of Professor Kaneyoshi Sawada material of this fungus has been obtained from Japan and examined in Pusa and found to agree with the Indian specimens. Specimens have been sent to Japan in order that a similar comparison may be made there.

(3) Fruit work in Kumaon. The root rot of apple and cherry trees due to a species of *Rosellinia* continued to cause a certain amount of loss. Some dead trees have been left standing in the hope that the perfect stage of the fungus will be produced and will enable the species to be identified. This disease was most severe on a section of the orchard which had been recently cleared of jungle and, as mentioned in the last report, is generally worst on the black soils which are rich in humus acids. It also appears to be favoured in situations where drainage is deficient, and extensive drains are projected on one orchard.

The apple cracking and branch blister, which was attributed to the fungus *Coniothecium chomatosporum*, was not so severe. Field observations have raised considerable doubts as to whether this disease in Kumaon is of the same nature as that described in Europe and South Africa under this name. Thus while the cracking of apples occurs on one variety, the branch blisters are present on two other varieties of which the fruit is undamaged. Further work

is necessary before the conclusions of previous authors can be entirely accepted. Spraying experiments with lime sulphur, Berger's lime sulphur and Burgundy mixture failed to check completely the disease. About 5 per cent. of the fruit of a certain variety, on both sprayed and unsprayed trees, was damaged.

Apple mildew (*Podosphæra* sp.) is perhaps the most widespread of the fungal troubles of apple trees in Kumaon. This disease seems to spread rapidly during the month immediately preceding the break of the monsoon. Spraying with lime sulphur during this period was not very efficient in controlling the disease, although in one or two cases, in which, at the risk of damaging the tree, a heavy application of double "summer" strength lime sulphur was applied, the disease was brought under control and infected shoots produced a further growth of healthy leaves. During 1918 mildew was especially severe on one orchard on which during that year no spraying had been carried out. In 1919 the spraying upon this orchard was done with a mixture containing iron sulphide, prepared according to the formula recommended for the Pajaro Valley, and mildew was very much less than in the previous year. Experiments will be carried out during the coming season to test the relative merits of iron sulphide and lime sulphur as sprays against apple mildew. Of the various varieties of apple, "Northern Spy" is the most liable to mildew in Kumaon, and serves as a centre of infection for other varieties. It is being destroyed on one orchard.

Fly speck and sooty blotch (*Leptothyrium Pomi*) is a disease which, while not actually damaging the apple, affects the market value of the fruit owing to the unsightly markings which it causes on the skin. This disease was much less severe on the trees which had been sprayed with lime sulphur than on trees which had not been sprayed at all.

Peach leaf curl (*Exoascus deformans*) had been serious in 1918, and in 1919 certain areas under peach were treated with lime sulphur, Burgundy mixture and Berger's lime

sulphur. All these sprays proved efficacious and there was not a single case of the fungal leaf curl in the sprayed areas. It was very interesting to note that one tree which had escaped the attention of the spraying gang became covered with the leaf curl.

During the progress of the spraying experiments in Kumaon striking differences were noticed both in the susceptibility of different varieties of apple to disease and their liability to spray injury from the different sprays. Future spraying experiments will be largely influenced by the information obtained in this direction.

(4) Chilli diseases. The study of the diseases of chillies has been continued by Mr. Dastur.

Further experiments in the treatment of "die-back" caused by *Vermicularia Capsici* Syd. did not give any definite results. The methods adopted were preventive spraying, shade, and late sowing. There was a failure of the monsoon in September and October, and the consequent dryness of the air, at the time when the normal high humidity and the susceptible stage of growth of the plant usually combine to produce an outbreak, prevented the fungus from developing, and the crop remained free from attack. It was, therefore, impossible to judge of the effect on the disease of the various measures tried. However, it is evident that an attempt to avoid damage from this parasite by sowing a month later than the usual time, so that the susceptible period when flowering occurs may be delayed to the drier period of the cold weather, is not likely to be commercially profitable. The yield of fruits obtained from the late-sown crop was very poor. Similarly the interculture of *rahar* (*Cajanus indicus*) as a shade crop between the rows of chillies had the effect of stunting the latter and cannot be recommended. Further experiments on the same lines are being continued this year.

The blossom and twig rot of chillies, caused by *Choanephora cucurbitarum* (B. & Rav.) Thaxt., which was mentioned in last year's report as having done considerable damage in 1917-18, was not observed last year on a single

plant. This suggests that the disease is dependent on humidity, the chief difference between the two seasons being the abnormal dryness of that under report at the flowering period.

Some damage was done by a new chilli disease, the cause of which is unknown. It starts from the base of the forked branches and is characterized by a dull black discoloration of the green bark which travels up the limbs and down the main branch. The black bark later becomes chalky-white, the appearance being quite distinct from that caused by die-back. On the white portions raised blisters appear and these crack longitudinally. As a rule the injury is confined to those parts of the plant facing south. No organism has as yet been detected associated with the diseased condition. The effect on the plant is to cause the upper parts to shed their leaves and gradually die back.

(5) Pythium disease of ginger, tobacco and papaya. The work on this disease, commenced about three years ago by L. S. Subramaniam, Third Assistant, was completed to a stage justifying publication recently, and an account of it is now in the press as a Memoir.

The parasite was first isolated from tobacco and subsequently from ginger and papaya. In all cases it proved to be the same species and the strains from tobacco and ginger were each found capable of attacking the other two hosts. It has also been found in nature to cause a damping off of chilli seedlings, and artificial inoculations with cultures from tobacco and ginger gave successful infection of chilli, castor and potato. The strain isolated from papaya has hitherto only been tried on the same host, but from its similarity to the others, and the readiness with which these attack the papaya and produce the typical symptoms, it may be expected that the papaya fungus will also attack the other plants mentioned. There is, therefore, so far as the experiments go, no indication that the fungus possesses specialized races.

On tobacco and chilli the attack is a simple damping off, similar to that caused by *Pythium de Baryanum.* Large

number of plants are sometimes destroyed in the seed beds from this cause in the neighbourhood of Pusa. On older plants attack cannot be secured unless the humidity is maintained at a high level, and such humidities are not usually found at any but the early period of the growth of the crop in Bihar. Natural attack on plants subsequent to the seedling stage have not been observed.

On ginger the disease has long been known and its field characters and control were described by Mr. McRae in 1911. It causes a soft rot of the rhizomes and base of the stem in several widely-separated parts of India, and is a disease of much importance to ginger cultivation. As the underground parts are attacked, the disease is found during periods when the soil is moist, and is chiefly confined to the monsoon and early part of the dry weather following. It may thus last almost up to the time when the plants are fully grown.

On papaya the attack usually takes the form of a foot rot of the base of the stem at or just above ground level. Sometimes the stem higher up is affected. Large areas of soft rotting develop and the tree is often ultimately blown over. As before, the progress of the disease is usually confined to the rainy season.

The fungus on ginger was formerly identified by the writer as *Pythium gracile* Schenk, but these further studies have led Subramaniam to separate it from that species, and he has named it *P. Butleri* n. sp. It is evidently a widespread and, at times, destructive parasite in India.

Definite suggestions for its control have been made, and tested experimentally with good results, by Mr. McRae for ginger and L. S. Subramaniam for papaya. Attempts to check it in tobacco seed beds have proved less successful. Treatment of the soil with the ordinary antiseptics usually recommended has failed, but a treatment by burning dry grass on the surface was effective on a small scale. Further work in this direction is required.

(6) Pigeon pea wilt. Work on this disease was continued by the writer in collaboration with Mr. Finlow,

Fibre Expert to the Government of Bengal. It has been noticed during the last few years that the incidence of wilt in the permanent manurial experiments on the farm varies greatly in the different plots, being less in those that have received no manure and more in those that have had mineral fertilizers. This occurred in both series of the experiments and was too clearly marked to be accidental. Its examination has been taken up in the hope that it may throw some light on the obscure problem of resistance and susceptibility to fungous diseases in plants. The cropping hostory and soil composition of these plots are particularly well known, and they have received uniform treatment for the past eleven years, so that they are very suitable for the purpose.

Two possibilities suggest themselves: either the treatment of the plots has in some way altered the composition or characters of the host plant, or it has influenced the parasite. If the former, it should be possible to correct the deleterious effect of the mineral fertilizers by appropriate manurial treatment, since it is presumably nutritional. For this purpose a second series of permanent manurial experiments has been laid down and artificially infected so as to produce a heavy attack of wilt in all the plots in the first year. If the condition depends on some effect of the mineral fertilizers on the parasite (which is a soil fungus), it should be possible to detect this by regarding the soil as a culture medium and examining its effects on the vigour or virulence of the fungus. For this purpose pot cultures with soil from the permanent plots have been started and have already given some interesting results. Attempts have also been made, hitherto without success, to determine quantitatively the amount of the parasite in the soils of the different plots, and it is proposed to test the effect of the soil solution on the growth of the fungus. Mr. Finlow has meanwhile carried out a complete ash analysis of the plant from several of the plots. The root development under different manurial treatments is also being examined. It is not expected that definite results will be obtained before several years.

(7) Sugarcane smut. Mr. Dastur has investigated the mode of infection of the sugarcane smut, *Ustilago Sacchari* Rabenh. It has been found that direct infection of thin varieties of cane can take place only in two ways: (1) through the young tender "eyes" and (2) through the older "eyes" when they are wounded or injured. Thick cane varieties can only be infected in the latter manner, and this is evidently one of the causes of their relative immunity to smut. The infection has not been found to take place through the cut ends of setts or through adventitious roots. The hyphæ enter the "eyes" through the unthickened scale hairs, and have not been observed to penetrate the epidermal cells directly. Inoculated plants have given smutted shoots in two months, while setts cut from canes, the dormant eyes of which were infected in the autumn, gave rise to smutted stools when sown the following spring. This explains why setts taken from stools which show no external signs of the disease can, when planted, give a smutted crop. Further work is in progress but the results already obtained mark a decided advance in our knowledge of the ætiology of this important disease.

(8) Rangoon bean. The disease of the Rangoon bean (*Phaseolus lunatus*) originally erroneously reported in the press as due to *Phytophthora* was investigated by Dr. Shaw during the past year. The attention of the Department of Agriculture, Burma, was first drawn to this disease by a European planter engaged in agriculture in the Kyaukse District. It is not improbable that the disease is of long standing as even now Burmese cultivators are reluctant to report its presence and may have had it for years without the local agricultural authorities knowing of it. The recent increase in the area under Rangoon bean ("pebyugale") and the method of cultivation which is practised, may have increased the amount of the disease, but there is no means of judging of the extent of the trouble prior to the first report.

The increase in the area under Rangoon bean, consequent upon the rise in price of this commodity during the war, led to the crop being grown in situations in which it

would not otherwise have been laid down. In particular, mango gardens were cultivated with "pebyugale" under the trees, and in such shaded situations the disease seems worse.

The method of cultivation takes no account of the habit of *Phaseolus lunatus*. This plant is a climber. It is, however, hardly ever grown as such, but the seed is broadcasted on the field and the plant is left to form a straggling growth. The result of this, and of the heavy sowing rate, is to form a dense mat of vegetation, about 18″ or more thick, all over the field. Within this light and air cannot penetrate and humidity is very high. The conditions within such a mat of vegetation are ideal for the development of any fungus, and particularly for a fungus which makes its most active growth at relatively low temperatures as does the present parasite.

In a publication of the Burma Department of Agriculture (Leaflet No. 47) it is recommended that the crop be sown in lines $2\frac{1}{2}$ feet apart. Where this advice has been followed, little or no disease can be seen and the yield of beans is actually improved, as where the plants are widely spaced a far greater number of flowers are borne and come to maturity.

The fungus possesses large black sclerotia with a septate mycelium bearing a conidial stage in the genus *Botrytis*. Upon damp sand or moist corn meal the sclerotia will germinate and produce long stalk-like structures. So far these stalk-like structures have failed to produce any fructification. During the forthcoming cold season infections will be carried out on a number of different species of *Phaseolus*.

(9) Other diseases. The rotting of stored potatoes is a serious problem in several parts of India, both as affecting potatoes stored for seed and as restricting the supply intended for consumption. Dr. Shaw visited Poona in November to see the potato storing system worked out by the Bombay Department of Agriculture in co-operation with a private firm, and to advise on the methods adopted.

Some 900 tons of potatoes intended for Mesopotamia had been dealt with in this manner very successfully. A fieldman has been placed in charge of experiments carried out during the present hot weather in the Punjab. The whole subject was discussed at length at the mycological meeting in February, and the directions in which further work is desirable were brought out. It seems probable that progress will be difficult unless some method can be devised of storing the tubers at a lower temperature than that to which they are habitually exposed in the areas concerned.

Rust in wheat was first observed in Pusa on 23rd December, when a few plants were found infected with *Puccinia triticina*. By the middle of January there were plants with uredo sori scattered throughout the crop. The last week of January was cloudy and 1½ inch of rain fell on the 30th and 31st. This led to a moderately severe outbreak of orange rust, which brought out the varying susceptibility of the varieties on the farm to a marked degree, some being almost free from attack while the ground under others was brown from the shed spores. *Puccinia graminis* was first observed early in March and did relatively little damage. *Puccinia glumarum* was not seen at all, a most unusual circumstance at Pusa. The Australian Federation wheat proved highly resistant to both rusts, while Mundi of Jullundar, Makhai of Chiniot, Pusa 4 and Cawnpore 13 were highly resistant to orange rust.

Dr. Shaw's work on sclerotial fungi was continued. The two diseases of sugarcane from the Central Provinces, referred to in a previous annual report, appear to be identical with the diseases known as Het Zuur Rot and Het Rood Rot in Java. The latter form, or one very closely resembling it, has also been collected upon jute (*Corchorus olitorius*) at Rajshahi, Bengal.

Field experiments with the "tokra" (*Orobanche*) parasitic upon tobacco were continued. A crop of tobacco from seed of *Nicotiana rustica*, obtained from Peshawar, was grown in an infected field. In Peshawar District tobacco

is not infected with *Orobanche*, and it was thought that possibly seed from this locality might give an immune crop. Such, however, was not the case as the crop grown from Peshawar seed was just as badly diseased from *Orobanche* as the crop from local seed in the same field.

A comparative study of the species of *Helminthosporium* found on cultivated cereals and sugarcane at Pusa has been commenced. Practically every cereal grown here is attacked by one or more of these fungi, but it is already probable that some of them are common to several hosts and that the total number of species is not large. The work includes morphological study based on cultures as well as inoculation work to determine the range of host plants of each species.

Some work on a *Sclerospora* found on *Andropogon annulatus* in 1918 was carried out, with a view to getting a clue to the method by which the allied cereal downy mildews are transmitted. This is entirely unknown. No results have, however, as yet been obtained.

Comparative studies of some species of *Phytophthora* have given results of interest. The American species *Ph. terrestria* Sherbakoff has been found to agree with the earlier described Indian *Ph. parasitica* by Mr. Dastur. Recently both this and another species have been discovered attacking coconuts in Jamaica, and the latter has been found to be one of the causes of bud rot in the West Indies. Cultures sent to the writer have proved to be identical with his *Ph. palmivora* first described under the name *Pythium palmivorum* in Memoirs, Dept. of Agric. India, Bot. Ser., Vol. I, No. 5, p. 82, 1907. It is evident that one form at least of this most destructive West Indian disease is caused by the same organism which has been so fully studied in India, and an old controversy is thus settled in a manner satisfactory to us. Some work has also been done on the species of this genus found on rubber, and has strengthened the view held in this laboratory that the forms hitherto found on this host in India and Burma are all belonging to the one species.

V. Miscellaneous.

During the mycological meeting in February, the greatest interest was aroused by the demonstration of fungi parasitic on man and the higher animals by Captain Froilano de Mello, Director of Bacteriological Services, Goa. Captain de Mello worked in the laboratory for about a fortnight with material brought from Goa as well as some obtained locally, and was able to give a detailed demonstration of the technique required for the isolation and cultivation of these fungi.

Mr. S. N. Bal, Assistant Professor of Botany, Science College, Calcutta University, spent about a fortnight in the laboratory in March and April, as he proposes to take up mycological work in Calcutta. Mr. J. C. Nag, Senior Professor of Botany, Presidency College, Calcutta, also visited us with the same object in view, in June. Economic mycologists in India will welcome the increasing tendency towards the study of the subject in other than its economic bearings in Indian Universities, as there is a great field as yet but little explored in this direction. Large collections of named fungi were given to Mr. Bal, Mr. Nag, the Central Hindu College (Benares), St. Xavier's College (Bombay), Baroda College and the Government College, Lahore. Some Indian *Loranthaceæ* were also sent to Professor Weir in the United States, cultures of *Phytophthora* to various enquirers and some fungi parasitic on scale insects to the Government Mycologist, Ceylon.

During the year a development of great importance for the co-ordination of mycological work in the Empire took place. Proposals by the Imperial War Conference for the formation of an Imperial Bureau of Mycology to be situated in London were accepted, and the Government of India have agreed to subscribe £250 annually for three years in the first instance towards its cost. The lines on which such a Bureau could be of most use to mycologists in India were discussed at the meeting of Indian mycologists in February,

and a detailed note on the subject was submitted by the meeting to the proper authorities.

The writer has commenced the preparation of a systematic list of the fungi of India, as the references are at present so scattered that it is almost impossible to get a general view of the composition of the fungus flora of the country.

VI. Programme of work for 1919-20.

(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*) Black band of jute.
(*c*) Chilli diseases.
(*d*) Fusarium wilts, especially in relation to soil and manurial conditions.
(*e*) Sclerotial diseases of jute, sugarcane, paddy and Rangoon bean.
(*f*) Orchard diseases.

Minor investigations will include the study of some fruit anthracnoses, *Orobanche* on tobacco, root rot of cotton, sugarcane smut, sal root rot and *Pythium* disease of papaya, ginger and tobacco.

(2) *Systematic work.* It is hoped to resume this with the facilities provided by the proposed Imperial Bureau of Mycology in London. Steps will be taken to supply the Bureau with representative collections from India. The preparation of a list of Indian fungi will be continued

(3) *Training.* This will be continued on the lines indicated in the prospectus.

(4) *Routine work.* Advice and assistance will be given to Provincial Departments of Agriculture and other departments and to the general public.

VII. Publications.

Butler, E. J. . . The Rice worm (*Tylenchus angustus*) and its control. *Mem. Dept. of Agric. India, Bot. Ser.*, Vol. X, No. 1.

Shaw, F. J. F. . . Report on Mycology, 1917-18, for the Board of Scientific Advice.

REPORT OF THE IMPERIAL ENTOMOLOGIST.

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

I. Administration.

The Imperial Entomologist held charge of the Section throughout the year ended 30th June, 1919, except for a period of one month from 9th September, 1918, when he was on privilege leave. The post of Supernumerary Entomologist, which had remained vacant for four years, was filled by Mr. M. Afzal Husain, M.Sc., who joined the Department on 6th January, 1919. Mr. Y. Ramachandra Rao, M.A., Entomological Assistant in Madras, was on deputation during the year to work under the Imperial Entomologist on an investigation of the insects which occur on *Lantana* in India and Burma; his period of deputation was completed on 31st March, 1919, after which he returned to Madras, and has since submitted a report on his investigations, which has been sent in for publication.

II. Training.

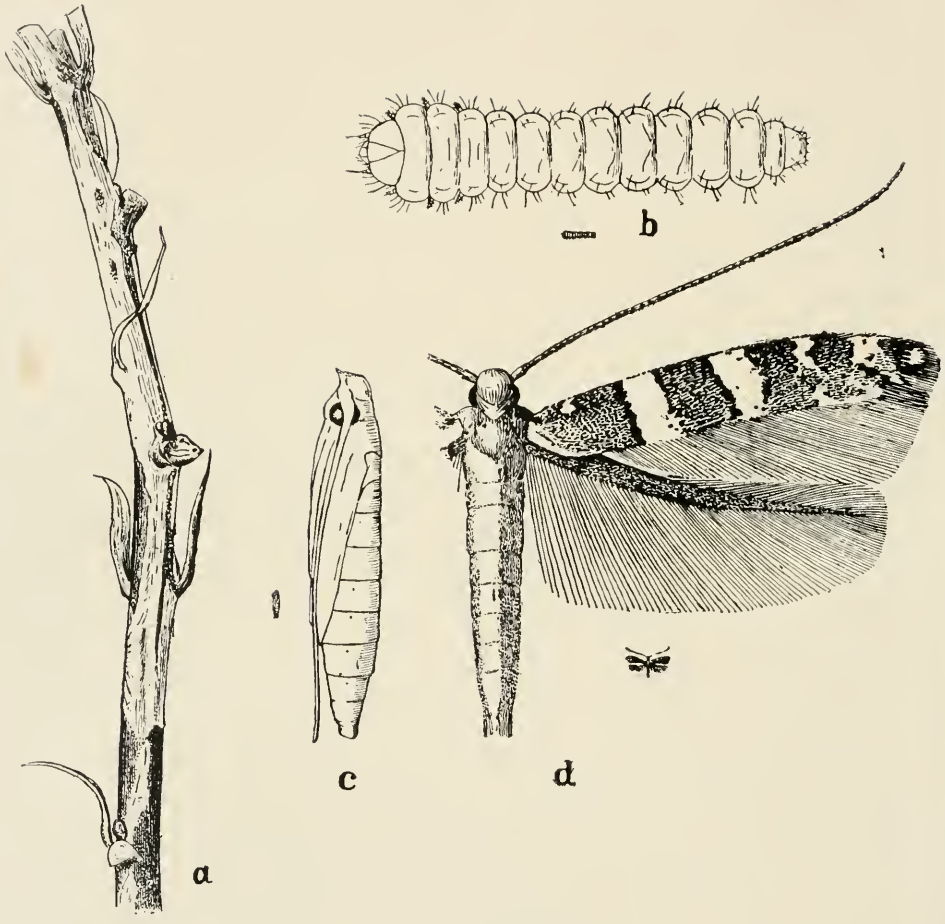
One student, Mr. G. D. Austin, deputed by the Ceylon Department of Agriculture, was received on 1st June for a course in Economic Entomology.

Mr. H. S. Pruthi, B.Sc., a student of the Government College at Lahore, was also received towards the end of the year and is working on the anatomy of *Dysdereus cingulatus*.

Four students completed a short course of instruction in sericulture and two in lac-culture.

III. Insect Pests.

A summarized account of our knowledge of Indian Crop-pests was given in a lengthy paper by the present writer read at the Third Entomological Meeting held at Pusa in February, 1919, and this information was supple-



Aerocercops sp.

a, Cotton branch attacked by larva.
b, Larva, dorsal view, natural size and magnified.
c, Pupa, natural size and magnified.
d, Moth, natural size and magnified.

mented by other papers, read at the same Meeting, on pests of cotton, fruit-trees, borers in sugarcane and cereals, etc. To these papers the following observations may be regarded as supplementary.

Cotton. The question of determining the relative immunity of the varieties of cotton was continued throughout the year, and it was found that certain varieties appear to enjoy a partial though not a complete immunity from bollworm attack. Work on these lines has been considerably hampered by the infestation of the cotton plants with *Pseudococcus corymbatus* and *Phenacoccus hirsutus* and later with *Eriophyes* sp. (probably *E. gossypii*). The unusual appearance of *Ps. corymbatus* was traced to a plot of soy bean closely adjacent to the cotton plots. The life-history of this Coccid has been worked out, together with those of its parasites and predators.

Hibiscus abelmoschus has continued to be a good trap-crop for bollworms, a larger number of parasitized bollworms being found in the shoots and pods of this plant than in either cotton or *H. esculentus*. As in the previous year the number of Pink Bollworms (*Platyedra gossypiella*) was found to exceed that of the Bollworms (*Earias* sp.) from October onwards.

Observations were made on a Bethylid (? *Parasierola* sp.) found in affected cotton-bolls containing larvæ of *P. gossypiella*. Another Bethylid has also been obtained from infected material received from Cawnpore.

In the search for alternative foodplants of *P. gossypiella* a large number of pods of *Thespesia populnea* was examined without result, but these pods were found to contain Phycitid larvæ boring in them.

A short note on cotton bollworms was read at the Third Entomological Meeting.

A Gracillariad (*Acrocercops* sp.) larva was observed to mine under the bark of cotton at Pusa (Plate VII). It is an extensive borer and causes a layer of bark to peel off the entire stem and even from the leaf stalks. This insect has not been noted on cotton previously.

Rice. Work on the borer pests of rice has been continued. By continued observation of the crop throughout the year and by actual counts it has been ascertained that the percentage of damage (about 29 per cent. on the average) given in last year's Report was exaggerated, due to the fact that this figure was arrived at by examination of the stubble only. Actually the damage done in the vicinity of Pusa does not seem to exceed about 4 per cent., but this cannot be taken as a normal figure for the more important rice-growing districts of India. The presence of unusually large numbers of the three principal borers in the stubble (*viz.*, *Schœnobius bipunctifer*, *Sesamia inferens* and *Chilo*) is due to the large pre-winter broods which, however, are not capable of doing much damage to the ripening crop.

A new external agent of damage has been discovered in the form of a Chrysomelid (Halticine) grub which bores into the stems of rice and millet seedlings from outside and causes a regular dead-heart. This insect has occurred in some numbers and ranks as a pest.

Sugarcane. Work on the borer pests of sugarcane and other gramineous plants was continued (1) to ascertain the effect of treatment of attacked canes by the cutting out of "dead-hearts," (2) to ascertain the species of borers in cultivated as well as in wild grasses, (3) to discriminate the various species hitherto confused under the name of *Chilo simplex* ("moth-borer"), (4) to find out the alternative foodplants of these various borers, (5) to trace out their seasonal life-histories and habits, and (6) to study other insects which are not actual borers but which affect the crop, especially the young sugarcane crop, in such a way as to produce effects similar to those caused by the actual borers; as these other insects occur along with the borers, their study is necessary in order to allocate the damage done to the actual agents.

As noted above, the preliminary results attained have been incorporated in a paper, by the present writer and C. C. Ghosh, read at the Third Entomological Meeting,

and it is therefore only necessary to give here a brief summary together with additional facts elicited since the preparation of the paper referred to.

Our experience, under conditions at Pusa, is that the treatment of borers by means of cutting out of "dead-hearts" is of no avail in sugarcane, especially in the case of the young crop, which is best left to grow undisturbed. Treatment by removal of "dead-hearts" seems distinctly injurious to the young crop by interfering with proper tillering. The borers which occur at Pusa (with the exception of *Scirpophaga xanthogastrella* which bores in the top-shoots) do comparatively little damage to the grown canes.

Reckoning all the dipterous maggots as one, since it has not yet been found possible to discriminate the different species of dipterous borers, over thirty different insects have so far been discovered to bore in sugarcane, rice, maize, *juar* (*A. Sorghum*), the smaller millets, and the various wild species of *Saccharum*. Of these, eleven occur in sugarcane, seven in rice, six in maize and *juar*, and four in the smaller millets. The borers in the wild species of *Saccharum* must be looked upon as potential enemies of the cultivated grasses also.

Up to the present, twelve different species have been discriminated amongst those previously lumped together as *Chilo simplex* ("moth-borer"). A key to the larval and pupal stages of some of these was given in last year's Report and a more complete key has been given in the paper referred to above. It need only be noted here, therefore, that the form referred to in last year's Report as ? *Chilo* sp. in rice (C. S. 1768) has since been found to be identical with the ? *Diatræa* sp. in sugarcane at Dacca (C. S. 1674; t. 7, ff. 1, 2), and that *Diatræa* sp. (C. S. 1610), found in sugarcane at Dacca and Pabna, has since been named *Argyria tumidicostalis* by Sir George Hampson.

The alternative foodplants of the various species have been given in the paper referred to. A new alternative foodplant, *viz.*, *Saccharum fuscum*, of *Scirpophaga xantho-*

gastrella has since been discovered; this is in addition to sugarcane, *Saccharum spontaneum* and *S. arundinaceum*.

The search for alternative foodplants has been continued as it has been observed in the case of several borers that the presence or absence of alternative foodplants influences to a great extent the prevalence of these borers in cultivated grasses. It seems possible that, by the use of these alternative wild foodplants, the prevalence of at least some of the borers may be reduced considerably in cultivated crops, but considerable further investigation along these lines is necessary.

The complete seasonal life-histories of twenty species of these borers has been traced out and incorporated in the paper referred to.

With regard to the external agents of damage, some further work has been done to attempt to find out what leads to the prevalence of termites in certain soils. Analyses of infested and non-infested soils have been made by the kindness of the Imperial Agricultural Chemist but further comparisons are required before anything more can be said on this subject.

In April 1919, three species of Dynastine beetles, *viz.*, *Alissonotum impressicolle*, *A. piceum* and *Heteronychus sublævis*, caused serious damage to sugarcane on the Kamrup Farm in Assam. Mr. C. C. Ghosh was sent to investigate the outbreak and ascertained that the beetles were breeding in large numbers amongst the roots of the various kinds of wild grasses growing over miles and miles of the waste land in the midst of which the Farm is situated, and apparently they occur there every year without doing noticeable damage to the cane crop. This year, on account of drought, the emergence of the beetles was deferred until rain fell in March, when an unusually large number of beetles occurred and attacked the crop, especially those portions of it where the germination had been retarded by the drought. *Heteronychus sacchari* has been recorded as damaging sugarcane but this is the first record in our experience of such extensive damage by adult beetles.

Observations have been made on the parasitization of *Aleurolobus barodensis*, an Aleyrodid destructive to sugarcane. It was found that the percentage of parasitization was highest at the end of November, 1918, when it varied between 80 and 95 per cent. For a few days the maximum was as high as 98 per cent. and thereafter the numbers of host and parasite rapidly declined.

A note on "Some Indian Economic Aleyrodidæ." comprising the species destructive to sugarcane, was prepared and read by Mr. C. S Misra at the Third Entomological Meeting.

Indigo. Investigations regarding the parasitization of the Indigo Psylla (*Arytaina isitis*) were continued throughout the year. Three species of Chalcididæ were concerned and of these one was very prominent. The parasitization was found to be highest at the end of May and September; after the latter date it declined gradually until the minimum was reached in February.

Mulberry. The disease known as "Tukra" or "Kokra" referred to in last year's Report, has been definitely ascertained to be caused by a mealy-bug, *Phenacoccus hirsutus*, Green, which is found on the plants together with *Pseudococcus virgatus*, Ckll. The nymphs as well as the adult females congregate on the shoots of the stems and cause the malformation which is so often seen in infested mulberry plantations. Not only is the growth of the plants retarded, but the lower lateral leaves become wilted and drop off. The affected apical leaves, if served to mulberry silkworms, cause "*flacherie*." Ten generations of *Phenacoccus hirsutus* were reared during the year and its parasites and predators were also studied, together with its means of dispersal as well as the best method of treatment of affected plots. Besides mulberry, this scale insect has also been found to occur on cotton, guava fruits, grape vines and fruits, and *Tecoma grandiflora*. Three species of Chalcididæ, as well as *Spalgis epius*, *Eublemma quadrilineata* and a Cecidomyiad fly, check this scale to a great extent. The presence of this mealy-bug is easily

known by the presence of ants (*Monomorium indicum*) which attend the scale-insects for the sake of their honey-dew.

A short account of the "Tukra" disease was prepared and read by Mr. C. S. Misra at the Third Entomological Meeting.

Fruit Pests. Special attention was paid during the year to the collection of information regarding fruit-pests. An Index to Indian Fruit Pests, summarizing the information to date under each plant attacked, was prepared and read by Mr. C. S. Misra at the Third Entomological Meeting, and the information under the various insects was also included in the Annotated List of Indian Crop-pests prepared by the present writer for the same Meeting. The information under this head has, therefore, been written up already, but the following short notes on new pests may be of interest.

Alcides mali, Mshll. MS. (Curculionidæ), was found at Shillong, the larva boring shoots of apple and causing a gall-like swelling. The adult weevil makes several, usually four, holes with its snout in a row in a tender shoot of apple and in one of these holes, and only in one, it deposits an egg. The larvæ tunnel in the stem, which becomes swollen in consequence. Pupation takes place in the larval tunnel. Control is practised by collecting the adult beetles as they rest on the twigs and by cutting off the twigs which show the punctures or the swelling caused by the enclosed larva.

Aclees cribratus, Gyl. (Curculionidæ), was found at Shillong in June-July 1918, the larva boring into the main stem of fig (*Ficus carica*) and doing considerable damage. The adult beetles occur on the stems by day and may be collected by hand although they readily drop to the ground when disturbed.

Deiradognathus (n. g., Curculionidæ, Mshll. MS.) n. sp., was found at Shillong in June-July 1918, the adults occurring on mulberry, apple, pear and fruit trees

generally, nibbling holes in the leaves and doing considerable damage, being present in very large numbers.

Dyscerus malignus, Mshll. MS. (Curculionidæ), was found at Shillong in June 1918. It is brownish-black with a conspicuous grey patch on the posterior portions of the elytra. The adult weevils feed on apple fruits, eating small punctures into them, and oviposit in small excavations along the edge of such patches. The eggs are large for the size of the insect, about 1·25 mm. in diameter, and are pearl-white in colour. The grub bores about in the interior of the fruit and damages it considerably. Pupation takes place inside the attacked fruits, which in the initial stages of attack are externally scarcely distinguishable from healthy fruits, but the invariable presence of a number of small whitish dots on the surface of the infested fruits marks these as attacked. These small dots are really holes through which the tunnels of the grubs communicate with the open air, and as a rule these tunnels originate at the apical end of the fruit, somewhere near the flower-scar, whence they ramify throughout the interior, branches being given off at intervals towards the surface where their termination is marked by the small dots mentioned above. In the later stages of attack, these holes become much larger and often exude a frothy liquid which attracts Sarcophagid flies.

This weevil was also found breeding in the fruits of *Prunus nepalensis*, a wild indigenous plum whose fruits are edible when ripe.

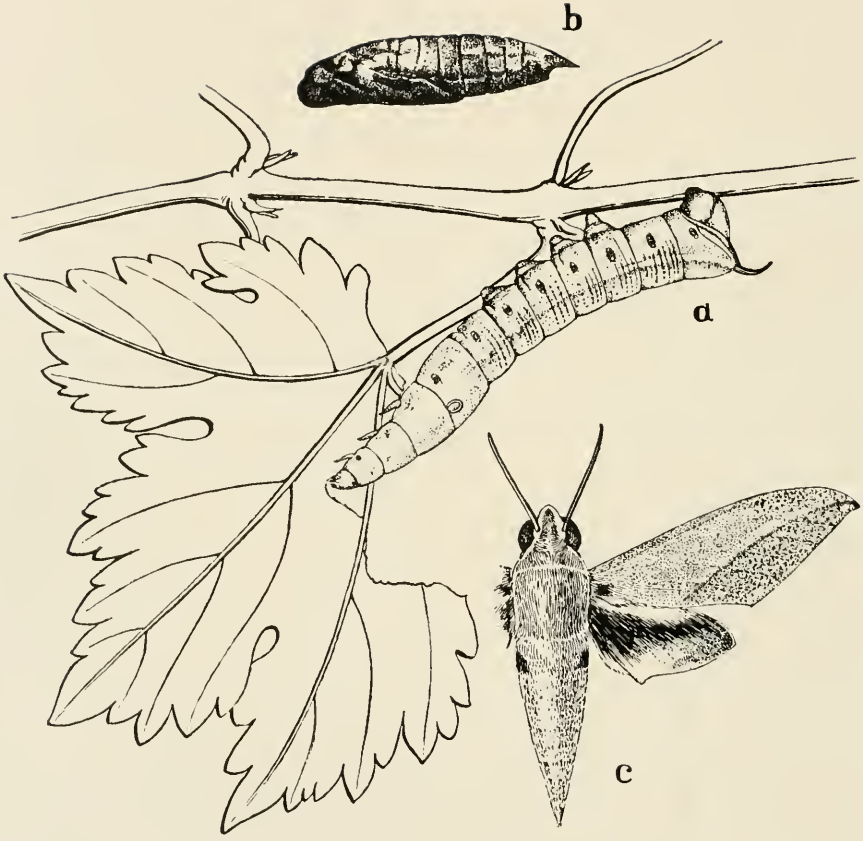
Dyscerus fletcheri, Mshll. MS., was also found at Shillong, the larva boring in apple fruits. The adult weevil is a reddish-brown species with scattered patches of greyish scales. It is rather larger than *D. malignus* but attacks apple fruits in exactly the same way, but pupation seems to take place sometimes outside of the fruit. The egg is about 1 mm. in diameter and rather dull-brown in colour. The larva seems quite similar to that of *D. malignus*. The adults appear to be long-lived, as an

individual caught in Shillong about 15th June and brought to Pusa, lived in the Insectary until 15th October.

Linda nigroscutata, Fairm. (Lamiadæ), was found at Shillong where the adults occur fairly commonly on apple trees in June and July, and were generally found resting on the shoots or leaves and occasionally feeding on the latter. In captivity the beetles fed on the leaves and also on the bark of apple twigs, but did not oviposit. Under natural conditions, however, the beetle girdles the twig more or less (usually rather less) completely, makes a slit at right angles to the girdling and above it, slightly detaches the bark on one side of this slit and thrusts in an egg under this loosened bark. The larva on hatching bores upwards into the twig and thrusts its longish pellets of frass out through holes cut in the twig, which of course dies off and shrivels up. This is a serious pest, doing considerable damage. The only control method possible is hand-collection of the beetles and cutting out of attacked twigs. No alternative foodplant is known as yet.

Chelidonium cinctum, Guer. (Cerambycidæ), was sent in from Bangalore by Mr. R. D. Anstead who found the larva boring into orange branches. The eggs are deposited in June in the axils of young living twigs and never on dead wood or old branches. The young larva bores into the twig and works upwards for a distance of about half-an-inch to an inch-and-a-half and then makes two tiny holes about the size of a pin's head; it then turns back and bores down the twig, occasionally making small openings; finally it gets into the main branches where it makes tunnels a quarter of an inch in diameter. The young twigs that are bored at once die and turn black, so that they are conspicuous and can be cut off with the larva inside them. By doing this and by hand-collection of the adults the attack can be controlled to a large extent.

Oxyambulyx sericeipennis, Butl. (Sphingidæ), occurred in some numbers at Shillong in July 1918 on walnut, each larva defoliating considerably, so that the damage may be fairly large in the case of young trees.



Theretra gnoma.

a, Larva, feeding on grape-vine leaf, natural size.
b, Pupa, natural size.
c, Moth, natural size.

Theretra gnoma, Fb. (Sphingidæ), occurred on grape-vine at Pusa (Plate VIII). This is a regular feeder on grape-vine and is a minor pest at times. It has also been reared at Pusa and Poona on leaves of "elephant's foot."

An undetermined Sphingid was found at Shillong as a serious pest of apple, and to a less extent of pear, about the end of June. It does considerable damage, as the larvæ are not easy to see in spite of their large size, and one larva will strip a whole branch of leaves. Pupation probably takes place under dead leaves in natural conditions. There is only one brood annually, the pupa hibernating. We have also had this insect sent in as infesting apple in Kulu. The moth has not yet been bred, but is probably *Langia zenzeroides*.

Actias selene, Hb. (Saturniadæ), occurs as a pest of apple in the Khasi Hills and Kumaon. It feeds on various other plants and has been found on pear and walnut, as well as on *Betula alnoides*, *Odina wodier*, etc.

Antheræa roylei (Saturniadæ) was also found attacking apple and pear at Shillong.

Heterographis bengalella, Rag. (Pyralidæ), occurs at Pusa every year as a minor pest of custard-apple, the larvæ tunnelling in the fruits. It appears to be common throughout Bengal.

Meridarchis reprobata, Meyr. (Carposinidæ) was sent in from Kashmir as boring and damaging cultivated olives. The larva feeds in the Plains in the fruits of *Eugenia jambolana*.

An unidentified Eucosmid larva was found boring apple fruits at Ramgarh (Kumaon) in much the same way as the notorious Codling Moth (*Laspeyresia pomonella*), from which, however, the Indian species seems to be distinct. The moth has not yet been reared out. This is likely to prove an important pest if it attains access to other apple-growing districts.

Acrocercops hierocosma, Meyr. ? (Gracillariadæ), occurred in numbers in litchi fruits at Pusa in May 1919.

A. hierocosma has been reared at Pusa in September and October from larvæ mining leaves of *N. litchi*. Only one moth could be reared from the larvæ in the fruits and this is slightly different from the leaf-mining form, although it is probably the same species. This fruit-infesting larva is referred to in *Indian Museum Notes*, Vol. V, pp. 121-122, t. 15, ff. 4, 4*a*, where it is unnamed.

Life-histories of Insects. Besides the various insects mentioned above, a large number of insects has been reared during the year and observations made on life-histories and habits. In a Report of this nature it is only possible to mention a few of these even by name.

(1) *Monohammus versteegi*. Eggs of this longicorn beetle borer in orange stems were collected in June 1918 at Haflong in North Cachar. The adult has been reared out and found to have one generation annually.

(2) Grubs of a longicorn beetle borer in jak stems (Plate IX, fig. 1.) were collected in Sylhet in June 1918. These are still (July 1919) feeding and will probably live another year, so that the larval stage extends over a period of two or three years in this case.

(3) *Cryptorrhynchus gravis*. This serious pest of mango fruits in Eastern Bengal and Assam was formerly supposed to lay its eggs in the flowers. This year it was definitely ascertained that the eggs are laid, not in the flowers, but in the fruits, even well-grown ripening fruits not being immune. The period of oviposition is an extended one. The shortest period for completion of the life-cycle is about three weeks or even less. Local observations and experiments extending over a whole year are necessary for the suggestion of preventive or remedial measures.

(4) *Balaninus c-album*. Short details of the life-history of this weevil infesting *Eugenia jambolana* fruits were given in last year's Report. A quantity of infested seed was kept buried at a depth of about two feet; no weevil succeeded in emerging from these seeds. Collection and adequate burial of the seeds should therefore keep this weevil in check.

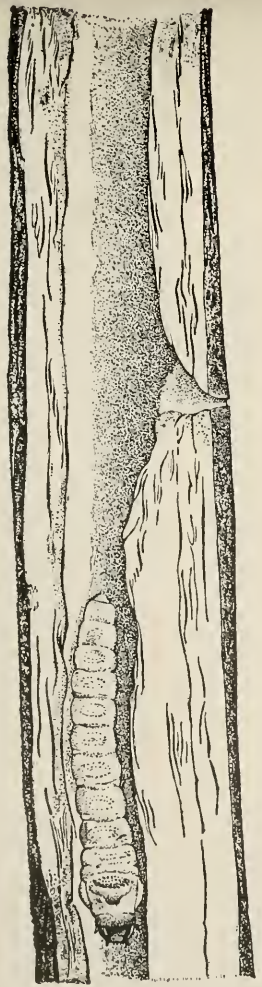
EXPLANATION OF PLATE IX.

Fig. 1. Longicorn beetle borer in jak stems

a, Section of jak stem, showing larval tunnel.
b, Full-grown larva, natural size.
c, Beetle, natural size.

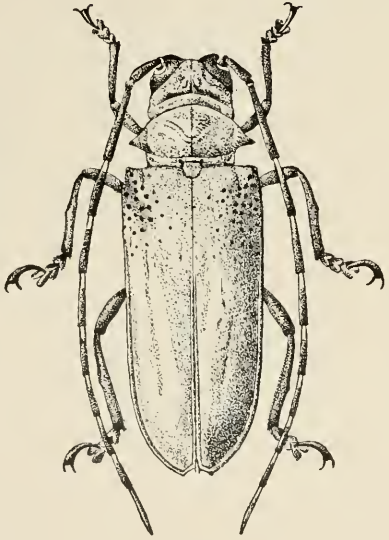
Fig. 2. Cecidomyiad on mango leaf.

a, Mango leaf, showing galls.
b, Adult fly, natural size and magnified.



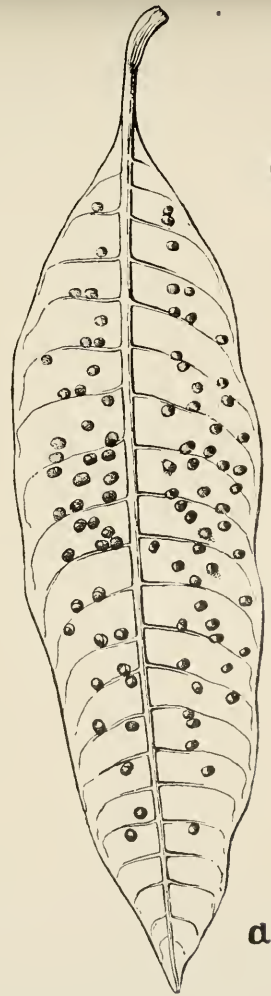
a

b



c

Fig. 1. Longicorn beetle borer in jak stems.



a

b

Fig. 2. Cecidomyiad on mango leaf.

PLATE IX.

(5) *Virachola isocrates* was found in small numbers in May 1919 infesting peach fruits at Pusa. This butterfly does not seem to have been recorded previously as attacking peach.

(6) *Earias fabia* and *E. insulana* have been found in fair numbers in the flower-buds of *Hibiscus rosa-sinensis.*

(7) *Heliothis peltigera* occurred in fair numbers in the larval state on leaves of *Carthamus tinctorius.* It is probable that this insect will prove to be a specific pest of safflower, but it has hitherto been overlooked and confused with *H. obsoleta.*

(8) *Platyedra gossypiella.* A sample of Cambodia cotton brought from Coimbatore showed that about 28 per cent. of the seeds had been bored by the caterpillars of this insect.

Grain Storage Experiments. These experiments were concluded and the results written up in a paper read at the Third Entomological Meeting and in which full instructions have been given regarding the methods to be adopted for storing cereals, pulses, etc., in order to keep them free from insects in the store-house.

Protection of wood against Termites. The results so far obtained have been embodied in a paper read at the Third Entomological Meeting. The work is being continued.

Lantana work. This work was taken up in November 1916 on instructions from Government, and has had 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, M.A., Entomological Assistant in Madras, was placed on special deputation under the Imperial Entomologist, and during the year under report worked in Assam, the Punjab, the United Provinces, Bihar, the Central Provinces and Madras. His period of deputation expired on 31st March, 1919, when he returned to Madras. A complete report on his work has been submitted for publication as a Memoir.

IV. Bees, Lac and Silk.

Bees. The work with the local variety of the Indian Bee (*Apis indica*) has been continued. There have been numerous inquiries on this subject during the year from residents in all parts of India. Improved hives have been prepared locally and supplied to various correspondents. Two show-cases, illustrative of bee-keeping, were prepared and supplied to the Agricultural Association, Muzaffarpur.

A Bengali Bulletin on Bee-keeping was published during the year and the first edition has already been nearly sold out.

A paper on "Bee-keeping in India" was read by Mr. C. C. Ghosh at the Third Entomological Meeting.

Lac. The emergence of lac larvæ took place at Pusa on 14th October, 1918, and 20th June, 1919. A small quantity of ber (*Zizyphus jujuba*) brood-lac was obtained from Malda, Bengal, to place on the trees. The October crop was fairly good but the June crop was poor, having been adversely affected by the unusually hot weather during May.

Two students were trained in lac-culture, and brood-lac was supplied to various applicants.

A note on lac-culture was prepared and read by Mr. C. S. Misra at the Third Entomological Meeting, and in April Mr. Misra attended the Meeting of the Board of Forestry where the question of developing the Lac Industry in India was discussed.

Silk. The Sericultural establishment is still on a temporary footing which has been extended up to 31st March, 1920. In the meantime work is being continued with the twenty multivoltine mongrel races of mulberry silkworms which have been established by crossing univoltine and multivoltine races. In these mongrel crosses it has been noticed that the yield of silk from the first generation of crosses is always better than that in later generations, which seem to deteriorate gradually. Attempts are being made to prevent this deterioration by the infusion of new blood in the mongrel races. We appear to have succeeded

in establishing a race which, on crossing with univoltine races, changes the resultant mongrel races into multivoltines in five or six generations, so that any univoltine races can be made multivoltine in a comparatively short time. Eggs of univoltine Chinese, Japanese, French and Bengali races and of a Japanese bivoltine race were sent for cold storage to Guindy, Shillong and Muktesar, and were successfully reared at Pusa in October and March.

Mulberry silkworm eggs have been supplied to Indore, Gwalior, Mysore, Banganapalle, Travancore, Mahlog (Simla), North-West Frontier Province, Northern Shan States, Nagano Sericultural College (Japan), to the different Salvation Army silk centres and to about 110 other applicants in all parts of India. Eri silkworm eggs have been supplied to Egypt, British East Africa and Japan and to about 75 applicants in India. Castor seeds and mulberry seeds and cuttings were also distributed to about 19 applicants. One Pusa reeling machine was supplied to the Agricultural Department, New South Wales, and another to Indore State. Silk exhibits were sent to various agricultural exhibitions and commercial museums. One rearer and one reeler were sent to the Saunders Weaving School at Amarapura (Burma), and one rearer and one mulberry gardener were sent to the Northern Shan States to start sericulture there. Many inquiries regarding rearing, reeling, dyeing, bleaching, spinning and twisting have been dealt with, and silk samples and bulletins on sericulture have been distributed to numerous correspondents. Silk pieces and castor seeds to the value of Rs. 2,071-3-4 were sold and the proceeds credited to Government, silk pieces to the value of Rs. 2,023-9-0 having been woven during the year.

Four students, two from Bihar and two from Bengal, completed short courses in sericulture during the year.

V. Illustrations.

Coloured plates illustrating the life-histories of the following insects were prepared during the year, *viz.*,

Laphygma exigua, *Oxyambulyx sericeipennis*, *Langia zenzeroides*, *Alcides mali*, *Brahmæa wallichii* and a sawfly attacking rose. Besides these, over four hundred illustrations in black and white were prepared in the course of the year and many of these have been sent in for publication in illustration of various papers read at the Third Entomological Meeting.

Considerable difficulty has been experienced in connection with the preparation of coloured lantern-slides of insect-pests, for which there is a considerable demand on the part of the Provincial Agricultural Departments. Towards the close of the year some sample slides, prepared by a new process, were obtained and, if these prove satisfactory, it is hoped that demands may be met.

VI. Miscellaneous.

Correspondence. A total of 74 parcels of specimens, mostly of crop-pests, was received during the year for identification and advice, whilst 805 letters were received and 1,083 issued; these numbers show a slight decrease on previous years but are exclusive of a large amount of routine correspondence which takes up a considerable proportion of time which should be devoted to more scientific work.

VII. Insect Survey.

Steady progress has been made in additions to and arrangement and identification of, the collection which is now a large and important one and continues to expand at a rapid rate. In view of the great value of this collection, both from an economic and systematic point of view, to future students of Indian Entomology, every effort is made for the proper preservation of the large mass of specimens, a task which is by no means easy in a climate such as that of Pusa. The more irreplaceable portions of the collection and those liable to most damage are therefore being placed in cabinets which are being obtained as rapidly as possible. The staff required for the upkeep (which includes the sorting and identification, as well as

the mere preservation, of the many thousands of specimens already accumulated and received every year) has not been increased since a time, many years ago, when the collection was comparatively quite small; yet this work is constantly expanding and has already become very heavy, although this is only one branch of the activities of the Entomological Section.

The war interfered considerably with the transmission of specimens for identification and later on the work entailed by the Entomological Meeting left little time for the sending out of specimens, but the following collections have been sent out to Specialists in the groups named and our thanks are due to them for the ready help afforded :—

(*i*) Microlepidoptera to Mr. E. Meyrick, F.R.S. Named and returned. The descriptions of numerous novelties are published in *Exotic Microlepidoptera.*

(*ii*) Diptera to Mr. E. Brunetti. Mostly named and returned.

(*iii*) Carabidæ to Mr. H. E. Andrews. Returned named.

(*iv*) Odonata to Major F. C. Fraser. Returned named.

(*v*) Stephanidæ to Mr. Elliott.

(*vi*) Ichneumonidæ to Mr. C. Morley.

(*vii*) Tenthredinidæ to Mr. Rohwer.

(*viii*) Bees to Professor T. D. A. Cockerell.

(*ix*) Dipteron parasitic on cotton mealy-bugs to Dr. L. O. Howard, Washington. Returned named as *Gitonides perspicax.*

(*x*) Tetriginæ to Dr. J. L. Hancock, Chicago.

(*xi*) Staphylinidæ to Dr. M. Cameron.

(*xii*) Curculionidæ to Dr. G. A. K. Marshall. Returned named.

(*xiii*) Scolytidæ to Mr. C. Beeson.

The following collections, sent out in previous years, have not yet been returned :—

(*xiv*) Histeridæ to Mr. G. Lewis.

(*xv*) Longicorn beetles to Dr. Gahan.

(*xvi*) Anthribidæ to Dr. K. Jordan.
(*xvii*) Rhynchota to Mr. W. L. Distant.
(*xviii*) Tetriginæ to Dr. J. L. Hancock.
(*xix*) Cicindelidæ to Mr. S. W. Kemp.
(*xx*) Aquatic Rhynchota to Mr. C. A. Paiva.
(*xxi*) Bruchidæ to Dr. G. A. K. Marshall.
(*xxii*) Hispinæ and Cassidinæ to Professor S. Maulik.

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

VIII. Third Entomological Meeting.

The Third Entomological Meeting was held at Pusa from 3rd to 15th February, 1919, and was well attended by delegates and visitors from India, Ceylon and Egypt. Over ninety subjects, mostly dealt with in written papers, were laid before the Meeting which may be said to have been highly successful. A short account was written for the April (1919) Number of the "Agricultural Journal of India," and a full Report of the Proceedings has been submitted for publication, so that it seems unnecessary to say more here except to affirm that such Meetings are of very real value and interest to all concerned in the study of Indian insects.

IX. Programme of work for 1919-20.

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, and of stored grain.

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.

X. Publications.

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

Dutt, G. R. . Descriptions of three male Mutillids from India. (*Rec. Ind. Mus.*, XVI, 259-261.)

Fletcher, T. Bainbrigge. Agricultural Entomology. (*Annual Report, Board Sci. Advice for India*, 1917-18.)

Fletcher, T. Bainbrigge. The Third Entomological Meeting. (*Agric. Journ. of India*, April 1919.)

Fraser, F. C. . . The hitherto undescribed female of the dragonfly, *Hemicordulia asiatica*. (*Journ. Bombay Nat. Hist. Soc.*, XXVI, 488.)

Ghosh, C. C. . . Bengali Bulletin on Bee-keeping.

Meyrick, E. . . Exotic Microlepidoptera, Vol. II, Parts 6-7.

REPORT OF THE IMPERIAL PATHOLOGICAL ENTOMOLOGIST.

(F. M. Howlett.)

I was in charge of the Section for the year, except for an absence on privilege leave from 9th to 23rd December, 1918, when Mr. Patel was in charge.

For practically the entire period, however, I was on special duty, in connection, firstly, with the prevention of surra-transmission by Tabanidæ, more particularly among transport camels, and, secondly, with the improvement of existing culicifuges for military use. Reports on the work done in these two directions have been separately submitted.

Little has been done outside these special enquiries, but Mr. Patel, besides continuing his work on midges and completing the manuscript of a book on cattle-flies, has studied the parasites of some animals and birds likely to be associated with human beings, and has made several new discoveries, including a blood-sucking muscoid larva with habits comparable to those of the notorious "Congo floor-maggot." Messrs. Sen and Sharma have continued, when circumstances permitted, the physiological work on mosquitos referred to in the programme for the year.

In January I attended the Science Congress in Bombay; in March the Veterinary Conference at Lahore; in April and May meetings of the Drugs Committee at Simla and the Surra Research Committee at Delhi.

The following papers were read at the sixth session of the Indian Science Congress held at Bombay:—

"Post-war Zoology" (Presidential Address to Zoological Section). F. M. Howlett.

"Tactics against Insects" (Evening lecture). F. M. Howlett.

"Life-history of a midge, *Culicoides oxystoma*, with some remarks on the early stages of *Ceratopogon*." P. G. Patel.

"The effect of mercurous chloride on the larvæ of *Culicidæ*." S. K. Sen.

"A preliminary note on the action of acids, salts and alkalies on the development of Culicid eggs and larvæ." H. N. Sharma.

Programme of work for 1919-20.

It is anticipated that the special enquiry on culicifuges may be continued, but orders have not yet been received. With this reservation, the main heads under which work will be carried on are as defined in last year's programme.

REPORT OF THE IMPERIAL AGRICULTURAL BACTERIOLOGIST.

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

I. Administration.

I was in charge of the Section during the year except for one month's privilege leave during September, 1918.

Captain J. H. Walton, Supernumerary Agricultural Bacteriologist, returned from military duty in Mesopotamia and Palestine after an absence of about four years.

II. Training.

Mr. K. Adinarayan Rao, a student from Mysore State, is under training in agricultural bacteriology, from 12th June, 1918.

Mr. H. S. Govinda Rao, a student deputed by the Mysore Government, to undergo training in laboratory technique in connection with silkworm diseases, worked in this Section from 17th December, 1918, to 26th June, 1919.

III. Soil Biology.

Nitrification. Field and plot observations of seasonal variation in nitrification in soils under crop and fallow were maintained; the results obtained confirmed the opinion that movement of soil water either upward or downward conduces to increased formation of nitrates; such movement may be caused by drainage, by surface evaporation, or by plant absorption (transpiration), this last factor accounting for the greater total nitrification found in cropped as compared with fallow plots. An important point affected by soil management seems to be the annual re-establishment of nitrifying flora to take the place of that eliminated by adverse conditions, such as waterlogging, during the monsoon; the success of this operation depends upon

recognition of the fact that nitrifying bacteria can perform their specific function under conditions adverse to their multiplication; such conditions include not only the presence of specific toxins but of excess of organic matter or of ammonia; the immediate oxygen requirements of the nitrifiers are generally satisfied in almost any soil but water-logging during the monsoon not only conduces to the development of toxin-producing bacteria but to the bringing into solution of excessive amounts of organic matter, all of which tend to depress the nitrifying flora as an indirect effect of anaerobic conditions. The addition of inert material of large superficial area such as broken brick or clinker appears to provide a suitable nidus for the development of nitrifying bacteria, not so much in the soil as on the surface of the broken material, thus setting up conditions similar to that in a sewage filter, where solutions containing concentrations of organic matter too high to allow of development of nitrifying flora are nevertheless nitrified by the organisms previously established on the broken surfaces. It is of interest to note that in experiments dealing with the addition of broken brick and potsherds to soil it is necessary to make allowance for the frequently high content of nitrate, generally as saltpetre, found in such materials in Bihar.

A considerable amount of work was done by the First Assistant on the different rates of nitrification of various organic materials in soil. These included various green manures and other plants, and oilcakes, and it was found that the non-nitrogenous portion had an inhibiting action upon the nitrification of the nitrogenous fractions. A paper on this subject was read by the First Assistant at the Indian Science Congress, Bombay (January, 1919).

Further experiments on the inhibition of nitrification by toxins resulting from anaerobic incubation of soils were carried out; it was found that nitrification did not begin for ten weeks in Omelianski solution made up with water extract of anaerobically incubated soil, whereas nitrification was complete in eight weeks in a similar solution but

from an aerobically incubated soil. Similar results were obtained when using pure cultures of nitrite formers seeded into these media.

The effect of excessive quantities of nitrogenous matter in inhibiting nitrification was tested in various soils; in Pusa soil 60 mgm. N per 100 gm. soil was found to be the maximum amount allowing complete and normal nitrification, either as ammonium sulphate or oilcake; when applied as a mixture of these two, however, it is possible to raise the combined amount to 90 mgm. without prejudicing the nitrification either by loss of ammonia or by delay. It is of interest to note that nitrification can take place even in a soil in which there is sufficient free ammonia to be detected by smell and litmus reaction.

Green-manuring. The green-manuring experiments carried out in collaboration with the Imperial Agriculturist on the Punjab experimental plots were continued. These experiments begin to show the valuable residual effect of such treatment on Pusa soils especially with fermented green manure (*Crotalaria juncea*). Incidentally most valuable and interesting light has been thrown upon the interpretation of the results of field experiments on such soils and in such a climate; the results obtained show clearly first of all the necessity of previously ascertaining the relative fertility of the plots before treatment and the absolute worthlessness of most manurial experiments without this precaution, and, secondly, the equal necessity of taking into account the effect of seasonal variation from one year to another. These points as illustrated by the green-manuring experiments referred to, are discussed in an article on this subject in the "Agricultural Journal of India" now in hand.

Biological analysis of soils. Further work was done on this subject and the question of the use of a standardized method was discussed at the Conference of Agricultural Chemists and Bacteriologists at Pusa in February. A special study was made of certain infertile soils (Manat) from the Konkan Division (Bombay). The First Assistant

visited this district and inspected the soils in the field and having carried out biological analyses in the laboratory a report with recommendations for treatment was written and submitted to the Director of Agriculture, Bombay.

Nitrogen fixation. The question of the nitrogen supply in Indian soils and exhaustion by the introduction of intensive cultivation and heavy-yielding varieties of crops was dealt with in a paper by me read at the Indian Science Congress in Bombay. In this paper attention was drawn to the danger of encouraging methods of exhausting Indian soils without making any adequate provision for keeping up the supply of the ingredients removed by increased crop yields; the loss of nitrogen especially must be guarded against when this takes place at a rate exceeding that of the natural fixation by legumes and non-symbiotic soil organisms. In this connection it was pointed out at the Conference of Chemists and Bacteriologists at Pusa in February, 1919, that special attention should be paid to the study of the conditions under which nitrogen fixation takes place in Indian soils, with a view to determining the possibility or otherwise of artificially obtaining optimum conditions for such fixation as a practical field measure. The very great variations in the amount of nitrogen fixed in the same soil in different years show clearly the possibility of influencing fixation by soil management without the necessity of adding impossibly expensive materials (such as sugar) to the soil. In the Punjab, nitrogen to the extent of 30 per cent. of that already present in a soil under single crop wheat, was fixed in less than six months in one season, whereas during the following one the amount was negligible. The possible symbiotic relationship between green algæ and nitrogen-fixing organisms in soils formed a subject for investigation at Pusa, by the Supernumerary Bacteriologist before the war as a continuation of his study of azotobacter in India and has now been resumed on his return from military service.

Further work on fixation of nitrogen by legumes was carried out and a memoir embodying the results was written

by the First Assistant. It was found that in cases, where nodule formation did not occur owing to the use of strains of the *radicicola* organism foreign to the plant, the latter nevertheless benefited by the supply of nitrogen a-symbiotically fixed in the soil to which such organisms had been added artificially. Similar results were obtained with azotobacter inoculation and by the growth of legume bacteria in artificial media separated from the soil containing the growing plant by porous cylinders. An interesting and important point was noticed, namely, that in the case of *B. radicicola* no residual nitrogen was found in the culture sand suggesting that fixation of nitrogen proceeded *pari passu* with its removal by the growing plant, whereas with azotobacter this was not the case. A modified medium (soil extract—mannite,—asparagin agar) was found to allow ready isolation of the organisms direct from soil.

IV. Indigo.

The isolation of considerable quantities of pure indican in the laboratory of the Indigo Research Chemist permitted the use of synthetic media for the cultivation of the various strains of indican hydrolyzing bacteria already isolated in the Bacteriological Section during two previous seasons on agar made up with indigo leaf extract. It was found that very little growth or hydrolysis took place in media in which indican was the only source of nitrogen, whereas the addition of small quantities of leaf extract activated this at once. Study of the physiological aspects of this question is being carried on.

Manufacture. Further experiments were carried out in the experimental factory on the hot water extraction method. Very good results were obtained by the use of lime precipitation following extraction and preceding inoculation with hydrolyzing bacteria; the improvement not only included higher percentage extraction of the indican present in the plant, but greater purity in the product. Experiments were initiated in the use of hypochlorite steri-

lization of the water and plant as an alternative to hot water extraction; this would be a very much cheaper method of eliminating undesirable bacterial flora than the use of hot water, but it is not yet clear whether it will be possible to obtain the high percentage extraction of indican given by the latter process.

A point of great practical interest arose during the first days of manufacture. It was found that owing to the "weathering" of the cement-lining surfaces of the vats during the months intervening between one manufacturing season and the next following one, lime was set free by disintegration in sufficient quantity to produce an alkaline reaction in the steeping water of such a degree as to interfere seriously with the growth and activity of the hydrolyzing bacteria; in this way fermentation was delayed to such an extent that even after twelve hours this process then normally complete was only just beginning. It was found necessary to add considerable quantities of acid (250 c.c. of 50 per cent. sulphuric acid per 600 gallons) to neutralize this alkalinity. There can be no doubt that a similar action takes place in all factories using cement-walled vats, and that the "warming up" of the vats commonly noticed at the beginning of each season is due partly to the removal of the disintegrated lime from the walls as well as to the gradual establishment of the necessary bacterial flora.

It is of interest to note here that numerous reports have been received from indigo factories of improved yields resulting from the use of cross walls or other methods of increasing the wall area of the vats, recommended (1917-18) as a result of the discovery of the importance of bacterial action in the fermentation of the indigo plant.

V. Pebrine.

Further study of the problem of elimination of this disease of the silkworm in India, included trial of the effect of hill-rearing upon the natural resistance of the larva to

infection. Experiments were carried out at Shillong during August and September; layings of eggs from Pusa were divided, half being reared at Pusa and half at Shillong; artificial infection was carried out at both places and it was found that even in the first generation a considerable increase in resistance to infection was obtained in the hill-reared larvæ. Eggs from the latter were transferred to Pusa both from infected and from disease-free moths, and further resistance to infection in the plains was noted in the latter, whilst in the former a smaller percentage of infected larvæ resulted from the hatching out of seed from the diseased moths; the infected larvæ also survived through a greater number of moults and a larger percentage of them attained maturity than is usual in such cases. It was also noted that the hill-reared worms produced better cocoons. It is proposed to continue this line of experiment and to recommend the institution of a central seed station at Shillong to provide ameliorated seed for the Indian industry. The revised method of examination of moths previously reported has been adopted by various grainages in India; the Sericultural Superintendent at Berhampore (Bengal) has reported favourably on his experience of its use during the last season. It is abundantly clear that owing to the use of multivoltine races in India and the generally insanitary conditions under which rearing is carried out it is essential for the rearer to begin his season with disease-free seed, in default of which the rapid cumulative effect of any small percentage of disease initially present, in the course of rearing the numerous broods characteristic of the multivoltine races, will inevitably result in the failure of a fatally large proportion of the worms. For this reason it is necessary to adopt in India a much higher standard of purity in the seed issued by grainages than is customary in Europe. A lecture on this subject was given at the Entomological Conference held at Pusa in February, 1919. A memoir on the mechanism of infection and the elimination of pebrine in India is now in the press.

VI. Sterilization of water.

Attention was drawn to this subject owing to the outbreak of a severe cholera epidemic in the neighbourhood of Pusa, and the difficulty of obtaining antiseptics. Attempts were made to obtain a stable hypochlorite solution by electrolytic methods and the work was transferred to Shillong whilst I was on hill recess there; owing to the kindness of the Director of the Pasteur Institute who allowed me to work in his laboratoy and the courtesy of the officers of the Local Government who allowed me to make use of the electric current supply of Government House, I was able to continue this investigation and was also fortunate enough to secure the assistance of Captain W. Hodgkinson, R.E., who was put on deputation by the Army Department for this purpose and has since been working on this problem at Pusa. It has been found possible to produce a solution containing from 3-4 per cent. available chlorine by electrolysis from purely Indian raw materials, thus avoiding the use of imported bleaching powder and having the consequent advantage of avoiding the great loss of chlorine in transit and in store incidental to the use of " bleach; " at the same time this solution (now known as E. C.) can be prepared anywhere where electric current is available, and can be made of standard strength merely by reading figures on an ordinary current meter without expert knowledge either of chemical or electrical methods. This work was done at the instance of the Stores Department of the Indian Medical Service with the object of providing a reliable method of sterilizing water for troops on field service or elsewhere; the principal difficulty encountered has been to obtain a sufficient degree of stability to allow of storage for such periods of time as may be necessary for transport to situations where electric current is unavailable; the degree of stability possessed by E. C., like that of all hypochlorite solutions, varies inversely with the temperature of storage, but owing to the method of preparation and the use of an appropriate stabilizer it should be sufficient to ensure its efficiency under most conditions

likely to be encountered. Further work is now being done to ascertain the most efficient form of apparatus for production of this solution on a practical scale.

VII. Programme of work for 1919-20.

Major subject.

1. Nitrogen fixation in Indian soils.

Special enquiries.

2. Indigo manufacture.
3. Pebrine disease of silkworms.
4. Sterilization of water.

Minor subjects.

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

VIII. Publications

Hutchinson, C. M. . Report on Agricultural Bacteriology, 1917-18, for the Board of Scientific Advice.

Hutchinson, C. M. . Nitrogen Fixation in Indian Soils. *Agric. Journ. of India*, XIV, 2.

Hutchinson, C. M. . Nitrogenous Fertilizers: Their use in India. *Agric. Journ. of India*, XIV, 2.

Joshi, N. V. . . Rate of Nitrification of different Green Manures and parts of Green Manures and the influence of crop residues on nitrification. *Agric. Journ. of India*, Special Indian Science Congress Number, 1919.

REPORT OF THE IMPERIAL COTTON SPECIALIST.

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

I. Charge.

I was in charge of the post throughout the year.

II. Cottons in the Provinces.

Bombay Presidency.

Khandesh. On the Jalgaon Farm, in East Khandesh, experiments have been continued to test the actual values of some of the inferior components of the local mixture, and of the Sindewahi Cross which was developed in the Central Provinces.

The local N. R. (Khandesh *neglectum roseum*) is declared to be good for spinning 10's. Poona N. R. and the local N. R. C. have no staple and, although the proportion of lint to seed is high, neither is worth any encouragement and they should be thrown out.

The cotton of the Sindewahi Cross is reported to be near *berar-oomra.* It is silky, of good staple, though rather variable, and it can spin 16's.

The money value per acre works out as follows:— N. R. C., Rs. 72-7-0; N. R., Rs. 69-10-0; and Sindewahi Cross, Rs. 62-12-0. These figures prove that, if cottons of better staple are desired by the trade from Khandesh, it must be prepared to pay a premium to compensate for the smaller yield to the cultivator who otherwise will continue to grow the cotton which gives him the greater profit. I would emphasize the necessity of maintaining on the Jalgaon Farm tests with the more valuable yellow-flowered forms of *neglectums* which do possess something in the nature of a staple.

Samples from five localities on the Nizam's Hyderabad-Godavery Valley Railway were grown for comparison on this farm. Messrs. Tata Sons & Co. carefully examined

the cottons grown from these samples and reported as follows :—" We have examined these five samples and all seem to have greatly improved on the Jalgaon Farm. We would strongly recommend the cultivation of *moglai* cotton seeds in the Khandesh tract. The samples have all obtained the characteristics of *moglai* cotton which is considered to be of good staple. That from Dharmabad comes first; from Purna, second; from Nander, third; from Parbhani, fourth; and Jalna, fifth. This judgment confirms the opinion that we expressed some years ago that a steady increase in quality occurs from Jalna onwards to Dharmabad.

" In Nander, there is such a great mixture of varieties of cotton that only a small number of bales of pure good long-stapled Nander is available.

" This year the rates of *moglai* cotton, such as Nander, etc., are about Rs. 70 lower than *broach* rates, but ordinarily they used to be very nearly equal or about Rs. 10 lower. All these samples are good for spinning 16's to 20's."

The value per *candy* (784 lb.) of these samples ran from Rs. 460 to Rs. 480, while those of the selections of N. R. cotton on the Jalgaon Farm ranged from Rs. 390 to Rs. 400, the value of *fine khandesh* cotton standing on the same day at Rs. 445. We have, however, no information regarding the acreage values of these *moglai* cottons.

We have arranged for the testing of yellow-flowered types of the local crop and the Sindewahi Cross against the inferior white-flowered types in alternate strips of moderate size, and these trials will have to be repeated for several seasons.

Southern Maratha Country. The type of cotton generally cultivated in Sholapur is the *jari* mixture of *neglectums* prevailing in Khandesh and Berar; in this mixture there are stray plants of *herbaceum* (*jowari hatti*) and Upland. The neighbouring tracts of the Nizam's Dominions produce a very high class of cotton from a type, in which *bani* predominates, known as " *karkheli.*" Before it is finally decided to introduce N. R. into this tract to the

exclusion of every other variety it will be advisable for the local department to give an exhaustive trial to the *karkheli* of the Nizam's territory which has a ginning percentage of 29-30, and to the yellow-flowered types of the local cotton including the Sindewahi Cross from the Central Provinces. All forms of *kumpta* are tested on the Dharwar Farm, and all Uplands at the Gadag Farm which enjoys the advantages of both the south-west and north-east monsoons, a condition essential for their proper cultivation.

On the Dharwar Farm, the following selections of *kumpta* have been under test for several years, and as regards merit they stand in the following order :—

Kumpta Selection (Dharwar I), an erect type, with short branches, chosen not only for the quality of its lint but also for its habit of growth, comes first, with an acreage return of Rs. 153-2-0, a ginning percentage of 29·1 and the value of lint Rs. 640, the ordinary *kumpta* with a ginning percentage of 25·2 being quoted at Rs. 625.

Kumpta Selection (Dharwar II), a bushy type, the prevailing one in the fields. The branches are longer than in the first. Its acreage outturn is Rs. 130-2-0, the ginning percentage is 29·3, and the lint is valued at Rs. 630 per *candy*.

When these selections were first made it was expected that the more compact growth of Dharwar I would allow of closer planting and therefore a higher yield, and this has been confirmed by the experience of several years. But the possibility of there being a difference in the lint also was never suspected, and this has been emphasized by means of reports from Messrs. Tata Sons & Co., who say that Dharwar I is decidedly superior in length of staple, while the cotton of Dharwar II is bulky and resembles more in appearance to what is called *Pivatney* (Foot-roll). *Kumpta ordinary*, cultivators' *kumpta*, gathered for the purpose of comparison was valued at Rs. 625. It has a ginning percentage of 25·2 and a lint value of Rs. 625. All the above samples were considered fit for spinning 24's to 30's.

At the Gadag Farm, experiments are conducted with different forms of Upland cottons known as Dharwar-American which, as has been stated, require both monsoons. Their cultivation is naturally restricted to the tracts where these climatic conditions prevail. They exist in the fields mixed with *jowari hatti* (*kumpta*) round Ranibennur. This mixture of Dharwar-American and *kumpta* cannot be treated as fraudulent, but must be taken as a precautionary measure on the part of the cultivators to ensure a crop from at least one variety. In a normal year the Dharwar-American ripens first and the crop is mostly off the land before the *kumpta* comes in so that both can be marketed at different times. The local department ought to work out the actual economic significance of this mixed cropping. The doubtful variety is Dharwar-American, as *kumpta* is more generally grown pure.

In 1912-1913, I pointed out that the deterioration of the Dharwar-American cotton had been caused by the mixture of Upland and New Orleans types of cotton, and arranged with the Director of Agriculture for the testing of the same. As a result of this test the Upland type has proved far more promising in outturn, ginning percentage, and the quality of fibre than the New Orleans type. The Upland type, on an average, gives 60 lb. more *kapas* per acre than the ordinary Dharwar-American mixture, gins 3 per cent. higher, and in value commands Rs. 15 more per *candy* of 784 lb. The following statement gives the average outturn and ginning percentage of the three types, which will be found to be of interest :—

Name of variety	Average outturn per acre for 6 years	Average ginning percentage
	lb.	
Dharwar-American (ordinary) . .	400	29·0
Upland type	467	32·0
New Orleans type	386	29·5

Samples from the Gadag Farm were arranged in the following order :—

Dharwar-American, Upland type selection, gave an acreage return of Rs. 142, a ginning percentage of 36, and a value of Rs. 640. The quotation for saw-ginned cotton on the day was Rs. 615. A sample of ordinary Dharwar-American gathered for comparison gave an acreage return of Rs. 92-8, a ginning percentage of 31·4 and a value of Rs. 620 per *candy*.

Dharwar-American, New Orleans type, gave an acreage return of Rs. 88-6-0, a ginning percentage of 32, and was valued at Rs. 630.

All these cottons are good for spinning 20's to 30's.

In order to ascertain whether the qualities of fibre, ginning percentage, etc., have any direct connection with the condition of the soil, a number of soil samples from representative tracts were taken and samples of cotton were also taken from the same lands.

The soil samples were submitted to Dr. Leather who made the following remarks after their examination :—

"The soils may be divided into two groups from the chemical standpoint, namely, those containing high proportions of carbonate of lime which are from the villages Bhilavadi, Miraj, Sangli and Bijapur, and the remainder which contain very much less. The former contain not only a high proportion of carbonate of lime but also a very low percentage of available phosphate and available potash. The other group consists of the remainder, namely, soils from villages Pachhapur, Dharwar, Huilgol and Halgali. All these soils contain, comparatively speaking, low proportions of carbonate of lime but rather more available phosphate and potash; at the same time, although the proportion of carbonate of lime in the soil from these four villages is low for black cotton soil, it is sufficient for ordinary agricultural needs.

"You will see that the chemical analysis does not divide the soils exactly as the physical analysis did, though one

can see the same classification on looking over both the elutriation and percolation tests figures. The soils from Bhilavadi, Sangli and Bijapur are physically imperfect and are in need of phosphatic manuring; the soil from village Miraj may not be physically imperfect, but it does require phosphatic manuring. Of the other group, soils from Pachhapur and Halgali villages seem to me to be likely to dry up very quickly but are from the chemical standpoint better off than the others. The soils from Dharwar and Huilgol villages although chemically and probably geologically the same as those from Pachhapur and Halgali, are physically different, especially that from Dharwar. I shall be very interested to hear from you what the agricultural differences are. I would certainly have thought that the soils from villages Bhilavadi and Sangli were agriculturally different from Miraj soil, although they are chemically so very similar; and in the same way I would have expected Pachhapur and Halgali soils to be agriculturally different from that of Dharwar, although here again chemically they are so similar."

As regards the classification of the soils by Dr. Leather, it will be seen that he divides them into two sections. The valuations of the cotton samples from the same fields prove that they arrange themselves almost exactly in the same order. Thus in Section I, Bhilavadi cotton was valued at Rs. 272, Miraj at Rs. 280, Sangli at Rs. 285, and Bijapur at Rs. 265; and in Section II, Pachhapur at Rs. 300, Dharwar at Rs. 280, Huilgol-Gadag at Rs. 290, and Halgali (Ranibennur) at Rs. 270. The rate of *ordinary kumpta* for the day was Rs. 275.

Gujarat. At Surat, attention is concentrated on the difficult problem of how to improve the *surat deshi* cotton which is very homogenous in character and is already the best of the indigenous cottons. Three strains have been isolated and studied: (1) 1027 ALF, (2) Selection IA, and (3) Selection II. For the first period of five years, the ginning percentages were: (1) 36·7, (2) 36·0 and (3) 35·7, respectively, and for the second period of the last three

years, they were (1) 34·5, (2) 36·6 and (3) 35·6. The ginning percentages of *surat deshi* for the same periods were 33·3 and 32·7. On this point alone it will be conceded that the cultivator gains in quantity by using one of the selections instead of his *surat deshi*. As regards the actual improvement of a selection, it will be useful to record the progress of 1027 ALF for the last 8 years. In 1912-13, it was reported to have acquired the characters of *surat* cotton with a slightly short staple; in 1913-14 it was considered almost equal to *navsari* in length and feel; in 1914-15 it was in no way inferior to *navsari*, long, silky, and strong; in 1915-16 the same remarks were made; in 1916-17 it was considered superior to *navsari;* in 1917-18 the same remark was made; and in 1918-19 it was reported as good, long-stapled, silky cotton and almost equal to Middling American. As regards production, the cotton of 1027 ALF was valued at Rs. 206-10-0 per acre, that of Selection IA at Rs. 192-12-0, that of Selection II at Rs. 155, and of the local *surat deshi* at Rs. 136.

For the current season the local department has distributed, in separate groups of villages, sufficient seed of Selection IA and Selection II to cover 5,000 acres, and a special staff has been retained to supervise all operations on these from sowing till the sale of their produce in the market.

For several years past the staple of *broach deshi* has steadily gone from bad to worse on account of the introduction of an inferior type of cotton known as *ghogari*. An experimental station was started in Broach to test the characters of *ghogari* as a pure crop, as its origin, history and nature were unknown. It has proved to be a prolific cropper of a grade of cotton resembling *bengals*, with a high ginning percentage. A number of forms were isolated and tested and none were found to approach *broach* in any way. The only alternative that suggests itself is that *broach* itself should be rigorously tested to see whether some form of it could not be developed to give a better profit than *ghogari*. The experiments at Ajupura have shown that

there is a possibility of this. If it can be proved that the cultivator loses nothing by abandoning *ghogari*, the authorities will be justified in prohibiting its cultivation. Messrs. Tata & Sons had the following remarks to offer on some samples of *ghogari* taken from the Broach Farm :—

"They have no staple at all (except one which seems to have a little) and they resemble *bengals* more than any other variety. We are given to understand that this type has not only taken a firm hold in the *broach* cotton tract but it has also extended into the Surat District. If this is the fact, it is greatly to be regretted, since it is not at all desirable that such a short-stapled type should be encouraged in Broach and Surat Districts. We would therefore strongly recommend that the department should take rigid steps to discourage the growth of such types in Broach and Surat."

I think that the possibility of identity between *wagad* and *ghogari* should be investigated by a local interchange of seeds, *viz.*, by testing *ghogari* (under proper restrictions) somewhere near Viramgaum and *wagad* at Jambusar. I am also of opinion that, at Dohad Farm in the Panch Mahals, experiments should be confined to the testing of *herbaceum* cottons of whose tract this area is a natural extension, and that it is not desirable to allow *neglectum* cottons a footing in a staple cotton tract.

At Ajupura, in the Kaira District, Selection IA from Surat, yielded 472 lb. of seed cotton (value Rs. 131 per acre) with a ginning percentage of 37·2, *wagad* gave 456 lb. (value Rs. 131) with a ginning percentage of 36·8, *ghogari* gave 411 lb. (value Rs. 117) with a ginning percentage of 36·8, and the local *kanci* gave 398 lb. (value Rs. 114) with a ginning percentage of 38.

Central India.

Samples of four cottons were received from the Indore Farm for valuation and remarks. They stood in the following order :—

(1) *Cambodia.* Value per acre Rs. 137-7-0, outturn 710 lb. seed cotton, ginning percentage 33,

valuation Rs. 460 per *candy*. This was sown under irrigation in May. This cotton has not got the appearance of Cambodia; the fibres are weak and staple short, about $\frac{3}{4}$ inch long. On the basis of *ujjain* at Rs. 520 on the day this may be valued at Rs. 570, Madras Cambodia selling for Rs. 650. A good sample of machine-ginned Cambodia has a nice golden tinge and a soft feel. The staple is about an inch long, spinning up to 40's. Gadag-Cambodia (roller-ginned) is only slightly inferior to the Madras-Cambodia but a saw-ginned sample is far inferior as the fibres are torn.

(2) *K 22* (an indigenous cotton evolved by Mr. Leake at Cawnpore). Value per acre Rs. 60-7-0, seed cotton 336 lb., ginning percentage 34, valuation per *candy* Rs. 415, good for 10's.

This also has deteriorated in the Central India soil and has acquired *bengal* style, having harsh feel and short staple.

(3) *Local Malvi.* Value per acre Rs. 58-9-0, seed cotton 356 lb., ginning percentage 30, valuation Rs. 430, and good for 10's.

(4) *Marwadi.* Value per acre Rs. 48, seed cotton 240 lb., ginning percentage 33, value per *candy* Rs. 475, good for 20's.

As regards future work in Central India, it should be emphasized that from the first the staff in charge should have a precise knowledge of what cottons actually exist in the tract and selections of all forms found in the field should be studied and tested on the experimental farm by officers who have had preliminary training in cotton investigation. The very fine variety *malvensis* is well worth detailed research and forms of it with a higher ginning percentage will undoubtedly be found if the search is conducted exhaustively.

Thanks are due to Messrs. Tata Sons & Co., Bombay, for their generous help in valuing the samples submitted

to them. This work takes up much valuable time which their staff have given ungrudgingly to assist us in the uphill task of effecting improvement in the Indian cottons.

III. Programme of work for 1919-20.

Major.

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

Minor.

(2) An enquiry into the manurial requirements of cotton will be made.

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

CALCUTTA : PRINTED BY SUPDT. GOVT. PRINTING, INDIA, 8, HASTINGS STREET.

SCIENTIFIC REPORTS

OF THE

Agricultural Research Institute, Pusa

(*Including the Report of the Secretary, Sugar Bureau*)

1919-20

CALCUTTA
SUPERINTENDENT GOVERNMENT PRINTING, INDIA
1920

Price Re. 1