List of Agricultural Publications in India during 1905-06 *and* 1906-07—concld.

No.	Title.	Author.	Where published.
		Entomology—contd.	
15	Direction for sending Insect specimens. (Leaflet.) Agricultural Research Institute, Pusa.	H. Maxwell-Lefroy, M.A., F.E.S., F.Z.S., Imperial, Entomologist.	Government Printing Press, Calcutta.
		Bacteriology.	
1	A note on the Inoculation of the soil for leguminous crop. Bulletin No. 1.	C. J. Bergtheil, Imperial Bacteriologist .	Indigo Research Station, Sirsiah, Mozufferpore.

G. I. C. P. O.—No. 21 I. G. Agri.— 9-4-08—1,500.—J. E. J.

REPORT

OF THE

Agricultural Research Institute and College, Pusa

(Including Report of the Imperial Cotton Specialist)

1907-09

CALCUTTA
SUPERINTENDENT GOVERNMENT PRINTING, INDIA
1909

TABLE OF CONTENTS.

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INTRODUCTORY.

THE reports of the Director and heads of sections of the Agricultural Research Institute, Pusa, and of the Cotton Specialist for the years 1907-09, are herewith published. The period ends on the 30th June 1909.

The Institute was opened for advanced students only in July 1908. Before this 22 probationers came from various provinces for technical training in various sections, to adapt them for work of a very practical kind in the provinces concerned.

It has been definitely settled that Pusa shall chiefly be a higher teaching institution with post-graduate studies principally for selected graduates of provincial agricultural colleges and distinguished science graduates of Indian universities. Arrangements have, however, been made, for the time being, to give in agriculture, economic botany and entomology, short courses particularly in regard to the practical application of these sciences to every-day agriculture or horticulture in India. I attach great value

to these practical courses. A prospectus of the Pusa College has, for general information, been published.

Before I review in short detail the work done at Pusa, there are a few features of this Institute which I wish to clearly define. The first refers to the general suitability of Pusa for the central research and experimental station for the whole of India. Pusa is a magnificent estate of over 1,300 acres, bounded on three sides by a loop of the little Gundak river. The soil is deep alluvial and is capable of growing successfully nearly every rain crop which can be grown in the plains of India. With irrigation from wells or from the river, it can grow successfully the majority of the more important garden crops. We have arranged for all necessary means of irrigation from the river and from wells, also for dealing with many important crops. The rainfall of Pusa and of Behar is generally secure, otherwise the district could not maintain its population of 900 to 1,100 per square mile. Pusa is situated in the heart of intensive agriculture which is largely controlled by a community of indigo planters. Agricultural improvements through their influence, can be brought to the notice of ordinary cultivators in a manner which is unique for other parts of India. This was one reason why Pusa was selected as the central research station. Mr. Coventry, an experienced indigo planter and an extensive experimentor in agricultural problems, was selected as the Director. He has very particular opportunities of spreading very far afield the results of the research work and of the practical field enquiries which are undertaken at Pusa.

We have at Pusa the Phipps' laboratory, a two-storied building, well-equipped with a laboratory for each branch of agricultural science and a physical laboratory. The main building also includes a library, museums for the various sections and the necessary lecture rooms. Quarters have been provided for the European and Indian staffs. There are recreation grounds, and I am glad to

say that the European staff, assistants and students are keen on sports. A hostel with accommodation for 70 students is provided, also a well-equipped hospital and dispensary.

All sections were very badly housed at Pusa in temporary laboratories for some time. The head of each section now rejoices in having a well-equipped laboratory with all necessary fittings and apparatus. The Institute is served by water-power and electric installations.

The amenities of the estate have been much improved in many ways. A new approach avenue to the Institute has been constructed, and the lawns surrounding the college building have been laid out under irrigation and sparsely planted parklike with trees and ornamental shrubs. The scrub and jungle growth on the estate has been mostly cleared, thus making preparation for bringing waste land under cultivation. The unsightly brick-fields near the entrance to the estate, have been levelled and are now under cultivation with suitable ordinary crops. An area of some 150 acres has been reclaimed for arable cultivation. Practically the whole of the estate is now under grass or cultivation.

It has been proved in the past that the Pusa estate is capable of growing very fine timber trees in the avenues and elsewhere; consequently we are endeavouring to improve the attractiveness of the estate by planting and protecting young trees in the pasture areas, along the frontage of the river and in the avenues. The existing teak, shishum, bamboo, and mahogany avenues are an object lesson to many parts of India. We even expect to improve upon these. The fruit orchards and botanical area are now attractive features. A large vegetable garden is maintained. Many suitable trees on the riverside land have been inoculated with lac.

Nineteen students in all the various sections were admitted for training in 1908-09. In regard to the scientific and practical teaching in the lecture rooms, in the laboratories and in the fields at Pusa, my chief desire is that it

should be a means of helping, in a very practical way, the ordinary or improved agriculture of this country. I wish, therefore, to attract, from provincial agricultural colleges and from other colleges, students of high class ability who have been reared on the land.

Many of such students are usually poor and cannot afford the expense of an advanced course in research work. Government have spent of late years large sums on the development of agriculture, and I am confident that Indian gentlemen generally interested in the work will do their share. There is perhaps no direction in which there is more scope for liberality of the most useful kind than in the founding of scholarships for students at Pusa.

I refer below to some of the work done in each section at Pusa and by the Cotton Specialist. A full review of each report is not required here.

Agriculture.—Mr. E. Shearer, Imperial Agriculturist, has done much useful work for the Department. He was absent on privilege leave from 2nd July to 30th September 1908, when his duties were carried on by the Director.

Permanent manurial and rotation experiments were laid down last year on two blocks of 9 acres each. The land selected for these experiments has been tested and found sufficiently uniform for the purpose.

Permanent pasture experiments were laid down in the monsoon of 1907. It is very important to know the best conditions in various parts of India under which pastures can, on practical lines, be properly established and improved. This is the aim of the Pusa experiments, and it is believed that the results will be of very wide application, especially as similar grass experiments have been undertaken in some provinces. Already there is a decided change in the character of the herbage in some of the manured plots at Pusa.

Arable areas which are likely to be suitable for the extension of experimental work in the future, are being treated uniformly in regard to cultivation and cropping.

The more important crops under trial at Pusa include wheat, barley, oats, maize, rice, various pulses, oil-seeds, sugarcane, jute, flax, and tobacco. Efforts are being made to obtain and acclimatise the best indigenous and foreign varieties of these crops. Cotton varieties have been given up, as nearly all are unsuitable to Behar.

Perhaps the most important line of work in the Agricutural Section at Pusa, refers to the breeding and rearing of farm live stock. A very select herd of Montgomery cattle, the premier milk breed of India, is maintained. A record of the milk yield of each cow is kept. It is hoped to raise the milking standard (which is now very high) by selection on the basis of these records, and to breed these cattle of one colour and of one type. I draw attention to an interesting illustrated note which will appear in the October number of the *Agricultural Journal of India* for 1909. It refers to a large and remunerative export trade in Indian cattle which has recently arisen. Probably no Indian breed will meet the requirements of this foreign demand better than Montgomery cattle. They are useful for milk, for work and for beef, and in South Africa, in the Southern States of America and in the Straits Settlements they must prove useful, because pure and half-bred Indian cattle have been found to thrive well in these parts and are not affected by flies and ticks in the same disastrous way as local cattle.

Last cold weather 80 Bikanir ewes were purchased. These are a white-fleeced breed with a high reputation for yield and quality of wool. They are being crossed by *dumba* rams to give them hardiness and obtain improvement in the crosses as mutton and wool sheep.

Poultry breeding is now conducted on a fairly large scale. During the last year 19 breeding pens of fowls representing 10 pure breeds and 3 crosses, have been maintained including turkeys, geese and ducks. The experience so far gained indicates that the breed of fowl fully suited to India will have to be developed by crossing.

With this aim in view various experiments are being tried at Pusa. Many enquiries are received for pure bred birds and for eggs for hatching. The farms in several provinces have been supplied with birds, and large orders are being booked from private individuals, chiefly in Madras and Burma Some of the pure and cross breeds reared at Pusa are being tried experimentally in the hills to determine how they stand the climate.

Botany.—Mr. Howard has done a great deal of useful work for the agriculture and horticulture of India.

He continued to be in charge of his section at Pusa except when he was on leave for six months from August 8th, 1907, to February 8th, 1908, when Mr. R. J. D. Graham, Supernumerary Economic Botanist, carried on the work of the section.

The most important work done by Mr. Howard during the period under report is in relation to wheat. He has nearly completed the botanical survey of the wheats of India. The results are given in the first section of his book, *Monograph on Indian Wheats*, now in the press. Samples of wheat were sent to Mr. Humphries in England for milling and baking tests, the results of which are published in a bulletin. At Pusa several promising wheats have been isolated by selection and are now being tested for yield, agricultural characters and grain qualities.

The plant-breeding work in wheat is now being conducted on a fairly large scale, and the separate cultures, many hundreds in number, extend over several acres. The main objects of this hybridization work are to improve the grain, straw and rust resistance of the Indian wheats. Considerable progress has been made in the investigation into the influence of soil, climate and moisture on the character of the grain in wheat.

Fruit cultivation on an extensive scale has been successfully established. Most of the fruit trees are coming into bearing. The fruit experiments at Pusa have already

yielded results of considerable practical importance. They have proved the suitability of the soil and climate in Behar for growing certain important varieties of fruit.

Preliminary experiments with high class fruit regarding sun-drying, evaporating and refrigerating, have been carried out. A method was devised and successfully tested for sending peaches long distances by rail in India.

During the past year a considerable amount of preliminary work was accomplished by Mr. Howard on oil seeds of the genus *Brassica*, and a general study of the oil seeds of India will be undertaken.

The races of both *Nicotiana rustica* and *Nicotiana tabacum* isolated at Pusa, have been studied. Arrangements have been made with the Peninsular Tobacco Company of Monghyr to conduct experiments at Pusa to ascertain the best varieties and the best means of growing tobacco suitable for the manufacture of cigarettes.

Selection experiments with flax, *Hibiscus canabinus* and *Crotalaria juncea*, were continued, and some promising races isolated.

Three varieties of sisal hemp (*Agave rigida sisalana*) have been established on a small scale.

Progress has been made in the investigation work with barley, *ganja* and opium. The study of the varieties of cassava has been completed, and Mr. Hector is preparing a final report on this subject.

Agricultural Chemistry.—Dr. Leather held charge of this section till 14th April 1909, when he went on leave, and the Supernumerary Agricultural Chemist, Mr. Annett, was appointed to officiate for him. Very few samples of agricultural materials are now sent up by provincial departments for analyses, as these departments have now their own chemists. An appreciable reduction has also taken place in the number of samples received from Native States, the Forest and Irrigation Departments and private persons. Dr. Leather had, therefore, more time for

original research and for larger investigations of importance to Indian agriculture generally.

The work in the pot-culture house has led to important field experiments, the results of which are likely to benefit cultivators at least in Behar in a very substantial way. These field experiments are devised to show that phosphatic manure can with economy and great advantage, be used for certain soils and many crops, particularly in parts of the Gangetic alluvium and especially in Behar.

The Imperial Agricultural Chemist has a very important investigation in progress on the effect of soil or manure on the composition of certain seeds. The results already obtained are remarkable. In conjunction with the Imperial Entomologist, Dr. Leather is investigating the prevention of injury by weevils to wheat and other grains when stored in bulk. This enquiry is of great importance, particularly as it is probable that the American "elevator system" of storing grain may be introduced into India at least on an experimental scale. Mr. Annett has conducted an interesting enquiry into the cause of the dark colour of the black cotton soil. The results of this enquiry are about to be published.

Mycology.—Dr. Butler held charge of this section till 31st March 1909, when the Supernumerary Mycologist, Mr. W. McRae, M.A., B.Sc., was appointed to officiate for him. Mr. McRae arrived in India after deputation for six months to the laboratory of Professor von Tubeuf at Munich. The transfer of the laboratories to the Phipps' building has greatly facilitated the work of this section.

Dr. Butler should be congratulated in regard to the practical application of his work to the ordinary conditions of Indian agriculture.

The requirements of provincial departments still continue to make heavy calls upon the time of the Imperial Mycologist. Collections are being accumulated and worked out with such voluntary assistance as can be got outside

India. Duplicate collections will be as far as possible supplied to provincial departments which already have mycological assistants.

The fungi hitherto recorded from India have been in great part identified, and the information has been made readily accessible.

The research work includes the examination of the life-history and general biology of parasites and their effects on the attacked plants.

The wilt diseases of cotton, indigo, pigeon pea and gram were selected for special study, and the results already obtained will largely help Indian agriculture. A memoir on the work is now in the press. The experiments at the Poona farm to raise a strain of pigeon pea resistant to the wilt disease, have been in progress for four years and are promising well.

Renewed experiments were made to elucidate the methods of infection of the red-rot disease of sugarcane which in India has been for a considerable period a very disastrous disease to this important crop. It is hoped that the new results will be published during the year, and advice of importance given. The study of the life-history of other sugarcane parasites has not yet reached the publication stage.

Dr. Butler inspected the palm disease operations in the Godavari delta in September and December 1907 and in January 1909. Successful inoculations with the parasite were secured during 1908, and a further study of its life-history was made. The campaign against this disease has been particularly successful, and is still being prosecuted earnestly by means of the special staff sanctioned by the Madras Government. I must note the fact that the results of this enquiry by Dr. Butler are so valuable to India that they are equivalent to saving the cost of his section to India for many years to come.

The Imperial Mycologist visited Travancore in September and October 1907 to investigate the cocoanut palm

disease that had broken out in that State. A report on that disease has been published.

The Imperial Mycologist visited Kashmir in 1908 during the months of July, August and September, and enquired into diseases of mulberry and of imported fruit trees. The result of part of this work has been published, and recommendations made for dealing with mulberry diseases. The problem is very important, as many poor people in Kashmir derive much benefit from the silk operations and from the cultivation of good kinds of fruit.

Dr. Butler will complete in a short time the text of a book on Indian plant diseases. It will be of great value to students of agriculture in India.

Entomology.—Mr. Lefroy held charge of this section during the period under report. His indomitable energy appears throughout the work of his section. He continued to direct the work of entomological assistants in the provinces, but their number is still only 13, which is quite inadequate to make an appreciable impression upon the agriculture of India. A beginning only has been made.

The teaching of entomology at the provincial agricultural colleges and also at demonstrations and at shows has made fair progress.

Attention has been given in provinces to the study of the life-histories and habits of injurious insects.

In the Punjab the effects of cotton boll-worm and its parasites has been closely watched.

The work on the insects of the plains of India was continued.

Assistance was given to firms dealing with *mohwa*, with brush-making and with cheroots in regard to insects damaging these articles.

Valuable results have been obtained in the cultivation of *eri*-silk during the past year on a small scale at Pusa, and it is intended to continue this as the basis of a small cottage industry in several parts of India. This industry

is being taken up in Tirhoot and Gujarat. The purely experimental work on *eri*-silk is almost completed. The cultivation of mulberry silk has been taken up.

The question of *tussar* silk is also being investigated.

The cultivation of lac was continued at Pusa as a demonstration to students and for much wider practical application in villages. Some owners of indigo factories in Behar have taken up lac cultivation on a fairly large scale. These men were supplied with seed and information, and their assistants were trained in lac culture. Assistance was also given to the Bikanir State in regard to the possibilities of lac culture there.

Mr. Lefroy has started apiculture with a few stocks of European bees to determine how far they thrive in the plains of India.

The Supernumerary Entomologist, Mr. Mason, visited the various centres at which army stores are baled and stored, to investigate the occurrence in clothing, etc., of the destructive insect *Anthrenus vorax*. On the completion of this enquiry recommendations were made for better baling. Mr. Mason continued the enquiry into the value of insect eating birds.

The general collection of insects of India apart from the purely economic one, has been completely arranged.

Enquiry into the question of preventing the introduction of fungus and insect pests by importation of plants and seeds was made in order to devise remedial measures

The text-book on *Indian Insect Pests* continues to increase in popularity. Its translation in Bengali has been prepared.

Mr. Lefroy's great work on *Indian Insect Life* has been issued.

A series of excellent coloured plates with short printed explanations illustrating injurious insects, have been issued for use in agricultural colleges, museums and farms and at

exhibitions and shows. This series will be continued and will cover silk, lac, bees and beneficial insects.

The best methods of preparing exhibits of injurious insects for shows are also being tested with a view to find out the class of exhibits that most appeal to the public. Further, a series of lantern slides in colour are being prepared in order that lantern lectures may be given at such shows.

Mr. Howlett, Second Imperial Entomologist, arrived at Pusa in December 1907. He has undertaken the investigation of those biting flies of whose habits little or nothing has been hitherto known in India. With a view to obtain materials for this enquiry, sets of apparatus and copies of the bulletin on biting flies, have been issued to persons and associations likely to render help. In this connection Mr. Howlett is in complete touch with special officers of the medical and veterinary departments. He arranged in February 1909 an exhibition of all kinds of blood-sucking and parasitic insects for the pathological section of the Bombay Medical Congress, and read a paper on the habits of sand flies. He has ascertained the life-histories of nearly all the mosquitos which occur in Pusa, and has found two species of fish which are capable of destroying large numbers of anopheles larvæ. A report on the natural enemies of mosquitos was furnished to the Director of Agriculture, Bengal.

A comprehensive investigation of the several species of fruit flies which attack mangoes, peaches, etc., is in progress. The life-histories of several of these have been worked out, and methods of destroying the mango fly have been tested with success. An attempt to check the annual attack of these pests on the peaches grown at Pusa, was so far successful this year that the period of severity was postponed; thus the Imperial Economic Botanist was able to complete certain experiments.

Mr. Froggatt, Entomologist to the Government of New South Wales, visited Pusa in June 1908, to obtain informa-

tion regarding the fruit flies in India, the Australian fruit flies being related to those found in India. Specimens have, therefore, been supplied to him.

Arrangements have also been made with Professor Silvestri to supply parasites of some of the South Indian species in the hope that they may be utilized against the olive fruit fly, a species which inflicts great damage in Italy.

Specimens have been lent to the Indian Museum, Calcutta, in connection with the revision of nomenclature of various groups of Indian diptera. A large representative collection of tabanidæ has also been lent to the British Museum to assist in like manner the revision of that family now in progress.

Mr. Howlett contributed to *Indian Insect Life* the portions relating to Diptera and the sections on Mallophaga, anoplura and cimicidæ.

A memoir on sand flies is under preparation in collaboration with Dr. Annandale of the Indian Museum.

Mr. Howlett controls the work of the artists at Pusa and is endeavouring to raise the standard of illustration work which is a most valuable part of the publications of the Imperial department.

Cotton.—Cotton continued to receive a great deal of attention from the agricultural departments. Mr. G. A. Gammie who has done much useful work in cotton, was appointed Imperial Cotton Specialist in December 1907. His report is separately published with those of the heads of sections at Pusa. It is unnecessary to minutely review it here. The co-ordination of the experiments that are being conducted on this crop, will now be possible, and Mr. Gammie's advice in the improvement of cotton ought to prove of great help to the department. The principal lines of improvement attempted have been (*a*) selection and distribution of cotton seed, (*b*) introduction of superior indigenous varieties and better methods of cultivation, (*c*) hybridization and (*d*) trial of exotic varieties.

(*a*) Selection and Distribution of Seed.—The distribution of seed of selected pickings from cultivators' fields, has been in progress for more than four years in several provinces, but without any marked result. This is hardly surprising, for such selection, while no doubt supplying sound seed, is, properly speaking, no selection at all, since the fields ordinarily contain many varieties mixed together. It is by separating types and continued plant-to-plant selection that real improvement can be effected. This line of work is now being followed on Government experimental stations with very encouraging results. On the Surat farm, the different types found mixed in Khandesh cotton have been isolated and have been sown separately to determine the comparative value of each. Similar experiments are in progress in Madras. At Akola in the Central Provinces promising work is in progress in the separate cultivation of the four distinct varieties of cotton which are now grown mixed by the *ryots* under the names *jari* and *kati vilayati*. Of these the *malvensis* seems to be a distinctly superior variety, and special attention is being directed towards selection from it.

Eight cotton seed farms were worked by private agencies in the Central Provinces in 1908 under the guarantee of the provincial department against loss. Such farms have been in existence for the last four years. They grow the ordinary *jari* and *bani* varieties of cotton, but are situated in districts which have special reputation for the high quality of their cotton. The seed of first and second pickings is purchased by the provincial department at more than market rates for distribution. In course of time when the selection now going on at the experimental stations has borne fruit, these farms will become useful agencies for the distribution of improved strains of seed. The ultimate object is to establish a number of such farms independent of the department, but receiving, when required, assistance in the provision of seed, trained staff or advice. In the Punjab, Bengal and United Provinces, selection of cotton seed is in progress.

(*b*) Introduction of Superior Indigenous Varieties and Beter Methods of Cultivation.—There has been a marked extension of this line of work, especially in Bombay and Madras. The introduction of Broach cotton into the Dharwar district has been attended with considerable success. This cotton is superior to the locally grown *Kampta* variety not only in quality, but also apparently in average yield per acre and in lint percentage. In 1908 sixteen thousand pounds seed of Broach cotton from Navsari were sown in these parts in addition to some of the seed of this crop grown locally in 1907. Steps are being taken to get the people to cultivate it properly and to adopt a cleaner system of picking. Some efforts were made to introduce Broach cotton under irrigation in the Deccan, but owing to faulty cultivation and irrigation on the part of the cultivators, the experiments were not successful. Attempts have been made to improve the quality of Broach cotton in northern Gujarat by introducing seed of the superior Navsari variety from the south of the district. In the Tinnevelly district of Madras the *karungani* variety has been found to be superior in quality and yield to the *uppam* variety. Arrangements were, therefore, made by the provincial department to sell pure *karungani* seed sufficient to sow about 8,000 acres in 1908. This work was partly helped by the grant from the British Cotton Growing Association. The Madras Agricultural Department has also made successful efforts to improve the *ryots'* methods of cotton cultivation. Expert cultivators are sent to teach the use of the country drill and bullock-hoe and to demonstrate the value of improved cultivation. Implements are supplied free of cost and expert labourers are sent to help the growers. The advantages of the drill are becoming widely appreciated, and in all 1,000 acres of private land were sown with the drill last year, and many *ryots* have learned to use the drill.

(*c*) Hybridization.—Experiments in hybridization were continued at several centres. They have brought to light

some new ideas which, however, require confirmation. The crosses at the Surat farm have been found to be undergoing considerable variation. Although their lints have a relative advantage in quality over the ordinary Surat cotton, the ginning percentage is steadily falling. (The percentage has fallen from 36·9 to 30·3 during the last five years.) The crosses have not yet been grown on a sufficiently large scale to properly test the outturn per acre. The lints of 21 hybrids grown on the Surat station were valued from 5 to 10 per cent. above fine Broach. At Dharwar some encouraging results have been obtained by crossing *inter se* newly introduced varieties from America and Egypt. Work on similar lines is being done in the Central Provinces and Madras, but until the hybrids show greater stability it is impossible to estimate their value.

(*d*) Trials of Exotic Varieties.—Trials of exotic varieties on Government farms and in cultivators' fields were continued. It is disappointing to have to record a set-back in the expectations previously formed regarding Egyptian cotton in Sind. Up to 1907 the area under this cotton was increasing, but last year, owing to the short supply of water till long after the proper sowing season, the area decreased, and the quantity and quality of the produce much deteriorated. Further, on account of faulty methods of cultivation, careless picking and admixture of leaves and dirt, the produce was so inferior that great difficulty was experienced in disposing of it. There were no bidders at the three auctions held in November, December and January last. The cotton was ultimately sold to a Bombay firm who wanted it for a particular trade purpose and paid only Rs. 9 per maund for *abassi* and Rs. 8-6-0 for *metafifi* as against a minimum of Rs. 11 per maund secured in the previous year.

The average outturn per acre of Egyptian cotton in Sind has been during the last four years much lower than that of the hardier indigenous variety and much less than was originally expected. This is mainly due to bad

cultivation on the part of the *ryots* who do not follow the instructions of the agricultural department. Unless cultivation is improved and sufficient flow irrigation is obtained as early as March-April, there is no likelihood of Egyptian cotton being established as a general field crop in Sind. The Government of Bombay are taking steps to secure these conditions. It is disappointing, however, to record that this year (1909) no sowings in Sind of Egyptian cotton have been made on account of the difficulties of water supply.

Some promising results have been obtained from the trials of American and Cambodia cottons in parts of the Southern Maratha country.

The area sown with American cotton in the Jhelum colony of the Punjab increased in 1907, but on account of the scarcity of labour due to the epidemic of plague, the area was restricted last year. There has been, however, no large decrease in the number of cultivators growing this cotton. Arrangements were made last winter to dispose of the produce by auction as is done with Sind-grown Egyptian cotton, and the results were most satisfactory, the cultivators obtaining an adequate price for their produce. The trials with Egyptian cotton in the Punjab have not yielded any satisfactory results. The Economic Botanist has now imported a new variety which he considers better suited to the Punjab.

Acclimatised American cotton was successfully grown in 1907 by many cultivators in the Aligarh district of the United Provinces, and there was a large increase in the demand for seed for the next year's crop. It is anticipated that the quantity of this cotton will soon be sufficient for putting it on the market on a commercial scale and the prices offered will determine whether it will be permanently established in these provinces.

In the Central Provinces and Bengal *burhi* cotton (an acclimatised variety of American type) has continued to give successful results. Efforts are being made to extend

the area under this cotton and to improve the quality and outturn by selection. In the Central Provinces arrangements were made during 1908-09 to secure a large supply of seed for distribution. It is a good cropper in districts of fairly heavy rainfall, yields a high percentage of lint of good quality and is comparatively immune to wilt.

In Madras and Burma, experiments with Egyptian and other varieties of cotton are in progress.

Tree Cottons.—Further trials with tree cottons have confirmed the opinion which I have previously expressed, *viz.*, that they will never enter into regular cultivation in India. The experiments made by Messrs. Shaw, Wallace and Company with this class of cotton have generally failed. The chief centre of their operations was the Mourbhunj Farm. One hundred and seventy acres were planted out with perennial cottons in 1907. In the succeeding year this area was increased to about 300 acres. In August 1908 the plantations were inspected by me in company with the Director of Agriculture, Bengal, and a report was submitted to Government. The experiments had failed and therefore have been abandoned since March, 1909. Some success has been obtained with the Bourdon variety in the Bombay Presidency and favourable results have been obtained here and there in Assam and Burma, but the place of tree cottons as a field crop in Indian agriculture is very limited.

J. MOLLISON, M.R.A.C.,
Inspector General of Agriculture in India.

SIMLA;
The 5th August 1909.

REPORT OF THE DIRECTOR, AGRICULTURAL RESEARCH INSTITUTE AND COLLEGE, PUSA, FOR THE YEARS 1907-09.

(B. Coventry, Esq.)

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1. *Charge.*—The Director returned from nine months' combined privilege leave and furlough on 27th November 1907, and for the remainder of the period under report, was in charge of his office.

2. *Staff.*—The European scientific staff of the Institute consisted as follows :—(1) The Imperial Agriculturist with one Supernumerary, (2) The Imperial Agricultural Chemist with one Supernumerary, (3) The Imperial Economic Botanist with one Supernumerary, (4) The Imperial Entomologist with one Supernumerary, (5) The Second Imperial Entomologist and (6) The Imperial Mycologist with one Supernumerary. Mr. C. J. Bergtheil, Imperial Bacteriologist, who for the last five years was on deputation with the Bengal Government carrying on investigations connected with indigo manufacture, joined his appointment at Pusa on the 1st April 1909, after the expiry of his deputation, but soon after (28th June) relinquished his post. Mr. F. M. Howlett, B.A., Second Imperial Entomologist, arrived from England on the 23rd November 1907 and commenced his investigation on *diptera*. Mr. G. P. Hector, M.A., B.Sc., arrived on the 14th January 1908 and took up the post of Supernumerary Economic Botanist in succession to Mr. R. J. D. Graham, M.A., B.Sc., transferred to the Central Provinces. Mr. W. McRae, M.A., B.Sc., Supernumerary Mycologist, arrived on the 28th March 1908. Mr. W. Roberts, B.Sc., Supernumerary Agriculturist, was deputed to Bombay Presidency in April 1908 to assist the Deputy Director of Agriculture, Mr. A. G. Birt, B.Sc., Supernumerary Agriculturist, was in May 1908 transferred to the Agricultural Department, Eastern Bengal and Assam, as Acting Assistant

Director of Agriculture. Mr. E. Holmes-Smith, B.Sc., Economic Botanist-designate of Burma, arrived from England on the 7th October 1908 to undergo training under the Imperial Economic Botanist, and Mr. G. C. Sherrard, B.A., Supernumerary Agriculturist, arrived from England on the 19th November 1908. Drs. J. W. Leather and E. J. Butler proceeded on leave from the 15th and 1st April 1909 respectively, and Mr. H. E. Annett, B.Sc., Supernumerary Agricultural Chemist, and Mr. W. McRae, Supernumerary Mycologist, were appointed to officiate in the posts of Imperial Agricultural Chemist and Imperial Mycologist respectively.

3. *Scientific Work.*—The scientific work of the Institute during the period is indicated in the reports of the various sections.

4. *College, Grounds, Roads, etc.*—The College building has been taken over from the Public Works Department and has been fully occupied by the various sections. The spacious compound surrounding the College has been laid out; a general improvement in the condition of the roads and avenues has been introduced. Nearly 150 acres have been added to the cultivated area.

5. *Students.*—The College was opened for students in July 1908. The number of students admitted during the year was 19. Of these, 2 came for training in practical agriculture, 2 in economic botany (one for a special course in fruit pruning and weathering), 2 in chemistry, 7 in entomology, 3 in mycology and 3 came for a general course in agriculture. Seven students left after completion of training; one left on account of ill-health, and one was recalled to his province before completion. The student from the Central Provinces who came for a training in entomology died before completing his course. In addition to the training in the agricultural sciences above referred to, special classes have been opened to give a short industrial training in subjects such as lac cultivation and sericulture, and there are now 2 students

receiving a course of instruction in the latter subject. In the coming year it is intended to enlarge these special industrial trainings by the addition of more subjects such as fruit-growing, poultry-management, dairying, etc. It is hoped that these short courses will assist in reviving several old industries and promoting new ones which may profitably be worked as cottage industries.

6. *Publications.*—Much assistance has been given by the senior members of the staff in the preparation of publications. Special mention should be made of Dr. Leather who has had charge of the photographic department, of Mr. Maxwell-Lefroy who supervised the passing through the press of all the illustrations connected with publications, until he handed over the work to Mr. Howlett, and of the latter gentleman who, during the last year, has not only been responsible for the preparation and publication of illustrations, but has also assisted much in seeing the printed matter through the press.

7. *Library.*—The library contains over 6,000 volumes. The transfer of the books from the old building to the new, their arrangement and cataloguing have taken up a good deal of thought and time, and I am greatly indebted for the assistance that has been given in these matters by Dr. E. J. Butler, Mr. H. Maxwell-Lefroy and Mr. A. Howard. A new catalogue, revised and corrected up to 31st December 1908, is in the press.

8. *General Health of the Station.*—The general health of the station has been good. There was an outbreak of chicken-pox and acute ophthalmia amongst the menial establishment in April 1908. In March 1909, there were four cases of confluent small-pox among the subordinate staff; all recovered, and by prompt disinfection and isolation further spread of the disease was stopped. In the hospital, relief was given to 5,716 cases of whom 190 were indoor patients. The number of cases treated amongst European officials and their families was 226. The operations performed numbered 171 of which 14 were major.

REPORT OF THE IMPERIAL AGRICUTURIST FOR THE YEARS 1907-09.

(E. Shearer, M.A., B.Sc.)

1. *Charge and Establishment.*—The Imperial Agriculturist was absent on privilege leave from 10th September to 4th October 1907, and from 2nd July to 30th September 1908, when his duties were carried on by the Director; for the rest of the period under report he was in charge of his section. Mr. A. G. Birt, Supernumerary Agriculturist, worked in the section until 8th June 1908, when he was deputed to Eastern Bengal and Assam to officiate as Assistant Director of Agriculture. Mr. G. C. Sherrard joined the section as Supernumerary Agriculturist on 20th November 1908. There have been no important changes in the subordinate staff. Excellent work has been done by Mr. Judah Hyam, Veterinary Overseer, who has been in charge of the breeding herds, Mr. Gulabbhai Desai and Mr. M. Ikramuddin, Farm Overseers, and Mr. Ziauddin Hyder, fieldman in charge of the poultry.

2. *Training.*—Four men from Eastern Bengal and Assam have completed courses of two years, nine months, six months, and three months, respectively, in practical agriculture. Of these, two are now in charge of experimental farms, one is a fieldman and the other who is a graduate in agriculture of Cornell University, United States of America, is temporarily in charge of the Dacca experimental farm, but is intended for the post of Agricultural Supervisor in his province. Two students sent by the Punjab Agricultural Department for the general course in agriculture, remained under training. Mr. Gore, Manager of the Salvation Army's farm in Gujarat, came for a short practical course last cold weather.

3. *Cropping and Character of the Seasons.*—The general cropping followed the same lines as in previous

years, being chiefly determined by the requirements of the breeding herds. Areas which promise to be suitable for future experimental work, have been treated uniformly with regard to cultivation and cropping, the produce of each acre weighed separately and the lands otherwise kept under close observation. Two blocks of 9 acres each were selected as suitable for the permanent manurial and rotation experiments referred to below.

The rainfall for the year 1907-08 was 32·35 inches (the normal being about 45 inches) and was badly distributed. There was a long break in the rains in July and August, and from the latter part of September till early January there was no rain. Cold weather sowings were made under very dry conditions, but the rains in the latter part of the cold weather were good. Notwithstanding the generally unfavourable conditions, the crops both *kharif* and *rabi* were excellent. The rainfall from the 1st of June 1908 to the 31st of March 1909 (which covers the *kharif* and *rabi* cropping seasons) was 18·23 inches. The monsoon arrived a full month later than usual and was very scanty, but *kharif* crops turned out to be little under the average. *Rabi* sowings, however, were made with very short moisture, and as practically no rain fell till the crops were in ear, the yields were reduced to less than $\frac{1}{4}$th of the normal. The experience of the last two years would seem to fix the minimum rainfall with which good *kharif* and *rabi* crops can be successively grown on the same land, as somewhere between 20 and 30 inches, if moderately well distributed. A considerable proportion of the rainfall is lost by surface drainage in heavy falls, so that the actual crop requirements are comparatively small. But it is only on very fine grained soils, such as the north Behar alluvium, where evaporation can be reduced to a minimum by suitable cultivation, that full advantage can be taken of the actual rain absorbed by the soil, and again suitable cultivation presupposes good cattle and efficient moisture-conserving implements which in this part of India are in the hands of few.

4. *Special Crops under Experiment.*—These included (*a*) sugarcane, (*b*) jute, (*c*) flax, and (*d*) tobacco.

(*a*) Sugarcane.—Experimental work on sugarcane is at present confined to determining the best varieties and the best conditions as regards cultivation, manuring, planting and irrigation. The results obtained will have only a local application, and it is recognised that the present work must either pave the way for larger investigations on this important crop, or, if local conditions are found to be unsuitable, work on the crop will be abandoned altogether. In the course of the last five years a large number of thick and of thin varieties of cane from all parts of India have been under trial. With regard to the thick varieties it has been found to be impossible, even with liberal manuring, to obtain the heavy crops grown in the best cane tracts, the maximum yield hitherto obtained being 35 tons of stripped canes per acre. The length and thickness of the individual canes are satisfactory, but the stools are deficient in tillering power, and the fact that many, from various causes, succumb altogether during the growing season, is further evidence of rather low vitality. The thin varieties, on the other hand, in most cases tiller extremely well, and with an application of oil cake or farmyard manure equivalent to 100lb of nitrogen per acre, and with one or at most two waterings after planting, can, in a normal season, be depended on to give yields of 30 tons of stripped canes per acre. This, considering the comparatively low expenditure on the crop, is quite a satisfactory return. Various sugar factories have been established in Behar in the last few years, and these deal almost entirely with thin canes. Provided the difficulty is overcome of securing from a moderate distance a sufficient supply of canes to keep the mills going, there appears to be no reason why these should not prove a success.

(*b*) Jute.—Forty-four varieties of jute were grown on an area of 8 acres in 1907 and gave an average yield of $16\frac{1}{4}$ maunds of fibre per acre, the season being no better than

the average with regard to moisture conditions. At one time there seemed to be a fair prospect of jute being grown in Behar on a large scale, but the difficulty of obtaining sufficient labour at the time of retting, the fall of the abnormally high prices of three years ago to their normal level, and the fact that in a very dry hot season like that of 1908 the crop may be a complete failure, has discouraged further cultivation. The Fibre Expert to the Government of Eastern Bengal and Assam has taken over the collection of varieties for classification and selection, but otherwise the crop is no longer grown at Pusa.

(*c*) Flax.—The results of the experiments with flax continue to be promising. In the *rabi* season of 1907-08 the yield and the quality of the flax straw were quite good, and there seems to be little reason to doubt that when the requirements of the crop are properly understood, flax will be capable of being successfully grown in Behar.

(*d*) Tobacco.—Zimmer's Spanish tobacco was grown on an area of 5 acres in the cold weather of 1908-09 for experimental curing in the curing house, but at the critical moment the expert assistance promised could not be obtained. In any case, owing to the unfavourable seasonal conditions, the crop was considerably below the normal both in yield and in quality.

5. *Manurial Experiments on Wheat.*—In the cold weather of 1907-08, calcium cyanamide and calcium nitrate were compared with sodium nitrate, Indian saltpetre, sulphate of ammonia, rape-cake and farm-yard manure as fertilizers for wheat. Owing to an attack of white-ants and the late application of the manures in a rather dry season, the results of the experiment were somewhat inconclusive, but calcium cyanamide and calcium nitrate proved as effective as any of the other manures except rape-cake. The readiness with which the latter manure becomes available as plant food, even under fairly dry conditions, is remarkable.

6. *Green Manuring.*—Green manuring has been very successful, especially in the case of lands newly reclaimed from jungle. By green manuring such lands, they are immediately brought into a condition of high fertility, whereas under ordinary conditions moderate fertility is only obtained after two or three years' cultivation. Sann-hemp is a crop ordinarily employed for ploughing in. It grows rapidly and gives a large bulk for ploughing in about the middle of the monsoon, and becomes sufficiently decomposed before the sowing of the succeeding *rabi* crop to avoid danger of the land drying out from being too loose. The effects of green manuring are very marked in the two following crops and are discernible for two or three crops more.

7. *Permanent Manurial and Rotation Experiments.*—These were laid down last year according to the scheme described in the Proceedings of the Board of Agriculture, held in February 1908. It will be after some years only that the results obtained will have their full value. The *kharif* yields varied, on the whole, very consistently with the doses of manure applied, thus showing that the land selected was sufficiently uniform for the purpose. The *rabi* sown plots were so poor as in most cases to be incapable of being harvested.

8. *Permanent Pasture Experiments.*—Owing to the ever-increasing contraction of grazing areas in India, it is of importance to know the best conditions under which good pastures can be established and maintained. That good pastures can be grown in many parts of India there is little doubt. An area of 80 acres of unmanured pasture at Pusa was found sufficient to supply all the green food required by two hundred head of cows and young cattle for six months in the year while yielding quite a substantial amount in the remaining six months. Consequently, a series of permanent pasture experiments was laid down in the monsoon of 1907 according to the scheme described in the Proceedings of the Board of Agriculture, held in

February 1908, and it is anticipated that interesting and valuable information will be obtained. Already there is a decided change in the character of the herbage in some of the manured plots.

9. *Breeding.*—The Montgomery herd of cows continues to do well. The high milking qualities of this breed are year by year becoming more appreciated, and dealers from distant parts of India now carry off large numbers from the half-yearly fairs at Amritsar. Out of the Pusa herd of 39 cows, 16 have given over 4,000lb each of milk in their last lactation period (under a year in each case), and of these five have given over 5,000lb each, one has given 6,300lb and another just under 6,000lb. When it is remembered that the average yield of milk in some of the best dairying districts in England, is said to be under 5,000lb, and with a considerably lower percentage of butter fat than is found in the milk of the Montgomery breed, it is possible to realise what a valuable asset India has in the latter. At Pusa there is now the nucleus of what promises to be a very fine herd, and the work of raising its milking power by selection based on the milk records, is probably the most important at present in hand in this section.

The local herd of cattle is still maintained on behalf of the Bengal Government. How far it is likely to prove useful is still uncertain. This year there was considerable difficulty in disposing of all the young bulls even at comparatively low prices. This may have been due to the scarcity of fodder in the district. There can be little doubt, however, that if the herd is to be fully successful, it must be transferred to the Bengal Agricultural Department whose officers alone are in close touch with the districts which the herd is intended to benefit.

During last cold weather 80 Bikanir ewes were purchased. These are a white-fleeced breed with a high reputation for yield and quality of wool. The change from the arid conditions of the Bikanir desert to the moist climate and new food of Behar, induced a severe attack of

dysentery from which 30 died in a short time. The remainder, however, are now doing well. They are being crossed by a *dumba* ram by which means it is hoped to obtain greater hardiness, constitution and earlier maturity. Attention will also be paid to maintaining the quality of the wool by careful selection.

Poultry breeding is now conducted on a fairly large scale. During the last year there have been 19 pens of fowls representing 10 pure breeds and 3 crosses. It is too soon yet to say how the imported fowls will do. The difficulties of disease and pests incident to the introduction of Western live stock of any sort into India, have had to be faced, and they have been formidable. In the light of the experience already gained, arrangements have been made which will obviate some of the difficulties encountered. Again, many of the more recently produced breeds of fowl are partly of Eastern origin, and for this reason and because of the greater vitality which has resulted from their mixed origin, adapt themselves with greater readiness to Indian conditions. The great fecundity of fowls, as compared with larger animals, is another factor in their favour. But, while there will always be a demand on the part of fanciers for pure breeds, there is little doubt that the breed of fowl fully suited to India will have to be built up in India, and with this end in view various crosses are being tried at Pusa.

10. *General Improvement of the Estate.*—Fully 100 acres have been added to the cultivated area. Much still remains to be done in the way of reclamation, but the back of the work has been broken, and as soon as sufficient work-cattle are obtained, this kind of work will soon be brought to a conclusion.

11. *Programme for 1909-10.*—The permanent manurial and rotation and the permanent pasture experiments will be continued. Experimental work on flax will be continued. Work on sugarcane will be continued. Barley, maize, sorghum, cow-pea, rice and castor varieties will be tested.

Breeding work will be further extended. Selection in the Montgomery herd on the basis of milk records will be continued. It is anticipated that the Bengal Agricultural Department will take over the herd of local cattle. Sheep breeding will be continued on the lines indicated in the report. The breeding and distribution of fowls will be continued.

The training of students will be continued. Attention will be paid to the general improvement of the estate.

REPORT OF THE IMPERIAL ECONOMIC BOTANIST FOR THE YEARS 1907-09.

(A. Howard, M.A., A.R.C.S., F.L.S.)

Charge of Office.—The Imperial Economic Botanist held charge of this section during the period under review, with the exception of six months from August 8th, 1907, to February 8th, 1908, when he took combined leave on account of illness, and Mr. R. J. D. Graham, M.A., B.Sc., Supernumerary Botanist, was placed in charge of current duties. While on leave he visited the various botanical gardens and experiment stations in Ceylon and spent some time at Peradenia, the head-quarters of the Ceylon Agricultural Department. He is indebted to Dr. Willis, the Director, for special facilities in studying the work and organisation of his department. Some new ideas were obtained which he hopes to make use of in India. Visits were also paid to some of the leading cacao, rubber, and tea estates in the island. Some work on geographical distribution was done at Newara Eliya, a paper on which it is hoped to publish shortly in England.

2. *Teaching and Training.*—The teaching work of the section commenced on October 1st, 1908, with two students from the Central Provinces. One of these was sent for a special course on the principles of fruit growing, the other for a general course of training in economic botany to fit him for the duties of first assistant to the Professor of Botany at the Nagpur Agricultural College. Both these students did excellent work and profited very considerably by their stay at Pusa. Two students from the mycological section attended the course of lectures and practical work on physiology in this section. During the present session two students from the Punjab have joined the section for a general course, and at least two more students

are expected in October next for the special course on the principles of fruit growing.

In addition to the external students, three supernumerary botanists have received training in the period under report. Of these Mr. R. J. D. Graham, M.A., B.Sc., left in February 1908, to take up the post of Economic Botanist in the Central Provinces. Mr. G. P. Hector, M.A., B.Sc., Economic Botanist-designate of Eastern Bengal and Assam, arrived at Pusa on January, 22nd, 1908, and remained under training. Mr. E. Holmes-Smith, B.Sc., Economic Botanist-designate of Burma, joined the section on October 12th, 1908, for six months' training in economic botany. This period has since been extended.

Mr. Abdul Rahman Khan, formerly Manager of the Lyallpur Farm, joined the section as an assistant on October 11th, 1908, and has undergone a special course of training since. He has worked well, has made a good deal of progress and has shown considerable aptitude for the work of plant breeding.

3. *Wheat Investigations.*—Considerable progress has been made with the investigations on Indian wheat. The quality of the wheat produced in India is a question of the greatest importance, both from the point of view of local consumption, and also of the export trade. Little attention, however, seems hitherto to have been paid to this matter. It appeared likely, both from the appearance of the grain and also of the nitrogen percentage, that some of the pure culture wheats at Pusa and Lyallpur were markedly superior in quality to the ordinary soft whites like Muzaffernaggar largely grown for export. Accordingly the co-operation of Mr. A. E. Humphries, a past President of the Incorporated National Association of British and Irish Millers and the highest authority in the Empire on the milling and baking properties of wheats, was secured with regard to the wheats of India. An arrangement was at the same time made with Dr. Leather, Imperial Agricultural Chemist, for the necessary analytical work to be done at Pusa. The first set of samples for

milling and baking tests were sent to England after the wheat harvest of 1908, and Mr. Humphries' report more than bore out the expectation that India can grow high grade wheats. This report was submitted for publication in the form of a bulletin in September last. Although several of the Punjab samples were superior to Muzaffernaggar white, Mr. Humphries considered that one of the Pusa selections, No. 6, was distinctly the best wheat. The publication of the bulletin has attracted a considerable amount of attention, and it was submitted by the Director of the Punjab Agricultural Department for the opinion of the Incorporated National Association of British and Irish Millers. The council of this association unanimously supported Mr. Humphries and Imperial Economic Botanist, and a full account of the proceedings is to be found in the *Miller* of May 3rd last, and was reprinted in the *Indian Trade Journal* of June 3rd, 1909. A second set of 28 samples of wheats was sent to England for testing during the present year.

Intimately associated with the quality of wheat is the question of the influence of such conditions as soil, climate and moisture on the grain characters. It was found in 1908 that the same sample of Muzaffernaggar wheat sown at Lyallpur, Muzaffernaggar and Pusa, gave rise to grain markedly differing in appearance, analysis and milling and baking qualities. In order to investigate this subject further, and also to discover experimentally a scientific basis for a scheme for wheat distribution in the Indo-Gangetic plain, this work has been considerably extended during the past *rabi* season in collaboration with Mr. H. M. Leake, Economic Botanist to the United Provinces. The co-operation of other officers of the agricultural departments was obtained, and experiments were successfully carried out at the following stations :—Pusa, Bankipore, Dumraon, Partabgarh, Cawnpore, Orai, Alighar, Meerut and Lyallpur. Mr. Evans has promised to assist next *rabi* at Hoshangabad. The results of this year's work will be

published as soon as Mr. Humphries' report has been received.

The botanical survey of the wheats of India was completed during the last year, and an account of this work forms the first section of the book, *Monograph on Indian Wheats*, now in the press. The report on the detailed agricultural survey of the wheats of the Punjab was completed during the year, and for this work the thanks of the Local Government were received through the Director of Agriculture, Punjab. A similar survey of the wheats of Bengal was completed during the year, and the results of this work will be published after the next *rabi* harvest. Bengal apparently possesses some wheats new to science.

Perhaps the most important section of the wheat investigations is that concerned with selection and hybridization at Pusa. Several promising wheats have been isolated by selection and are now being tested for yield, agricultural characters and grain qualities. The plant-breeding work is now being conducted on a large scale, and the separate cultures, many hundreds in number, extend over several acres. The main object of this hybridization work is to improve the grain, straw, and rust resistance of the Indian wheats. The results already obtained are of the very greatest promise.

During the progress of the wheat investigations at Lyallpur, a comparison was made between the wheats of the Punjab and those of the United Provinces. The superiority of the former in vigour and straw characters was most marked. Accordingly during the past year a set of the types of Punjab wheat was placed at the disposal of the Economic Botanist, United Provinces, for growth at Cawnpore. The result surpassed expectations. These wheats showed a marked superiority over the other wheats cultivated at this station, and Mr. Leake has arranged to continue the testing of these wheats in the United Provinces. Besides the report on the Punjab wheats and the

bulletin on the milling and baking tests, two publications on this crop have been completed during the year. A memoir on *The Varietal Characters of Indian Wheats* has been published. Three papers on wheat dealing with the results obtained in the harvest of 1909 are in preparation.

4. *Fruit.*—The fruit experiments at Pusa have already yielded results of considerable practical importance, but it was impossible to find time to write during the last year a second report giving an account of these results. It is hoped, however, to take up this work shortly. Good crops of oranges, limes, custard apples, peaches, plums, guavas, and loquats were grown, and the litchis and mangoes are coming into bearing. Preliminary experiments on sun-drying, evaporating and refrigerating, were carried out, and a method was devised and successfully tested for sending peaches long distances by rail in India.

5. *Fibres.*—Selection experiments in the case of flax *patwa* (*Hibiscus cannabinus*) and sunn-hemp (*Crotalaria juncea*) have been continued, and some promising races isolated. Three varieties of sisal-hemp (*Agave rigida sisalana*) have been established on a large scale.

6. *Oil Seeds.*—During the year a considerable amount of preliminary work was accomplished on the cultivated oil seeds of the genus *brassica*, and the study of the oil seeds of India will be considerably developed during future years.

7. *Minor Investigations.*—The study of the cassava varieties has been completed, and Mr. Hector is engaged in the preparation of a final report on this subject. He has completed the botanical examination of the Pusa pasture experiments, and the final report has been submitted. The work on *ganja*, barley and opium has been continued.

8. *Tobacco.*—A good deal of attention has been paid during the year to tobacco. The races of both *Nicotiana rustica* and *Nicotiana tabacum* which have been isolated at Pusa, have been studied. A memoir summing up

the work on the yellow flowered tobaccos of India (*Nicotiana rustica*) has been submitted for publication, and a second memoir dealing with the classification, description and biology of the races of *Nicotiana tabacum*, is in preparation. The method of growing this crop by furrow irrigation, was further tested and improved during the year. Arrangements have been made with the Peninsular Tobacco Company of Monghyr, to conduct a series of experiments at Pusa to ascertain the best variety and the best means of growing tobacco suitable for the manufacture of cigarettes. This work will be conducted in collaboration with one of the experts of the company.

9. *Programme for 1909-10:—*

(*1*) Training.—The teaching work of the section will be continued on the lines laid down in the prospectus of the Institute.

(*2*) Plant-Breeding and Plant Improvement.—The following crops will be studied:—Wheat, tobacco, barley, oil seeds and fibre plants.

(*a*) Wheat.—The botanical and agricultural survey of the wheats of Bengal will be completed on the lines adopted in the investigations on the Punjab wheats. The production of improved varieties by selection and hybridization, will be continued as well as the investigation of the factors influencing the quality of the grain.

(*b*) Tobacco.—The botanical survey of the Indian tobaccos will be completed.

(*c*) Oil-Seeds.—The study of the oil-seeds of India which has been carried on on a small scale during the past year, will be extended on lines similar to those adopted in the investigations on wheat.

(*d*) Barley.—The work on this crop will be continued.

(*e*) Fibres.—The collection and investigation of fibre yielding plants will be continued.

(*3*) Fruit Experiments.—The permanent experiments on the culture of Indian fruits will be continued on the lines laid down in the first report.

(*4*) Minor Investigations.—The economic importance of the male plant in *ganja* cultivation and the problem of the inheritance of sex, will be determined. The study of cassava as a famine food will be continued in collaboration with Imperial Agricultural Chemist.

REPORT OF THE IMPERIAL AGRICULTURAL CHEMIST FOR THE YEARS 1907-09.

(J. W. Leather, Ph.D., F.I.C., F.C.S., and H. E. Annett, B.Sc., M.S.E.A.C.)

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1. The Imperial Agricultural Chemist held charge of this section till April 14th, 1909, when he proceeded on leave, and Mr. H. E. Annett, B.Sc., M.S.E.A.C., Supernumerary Agricultural Chemist, was appointed to officiate for him. Mr. Annett acted as Agricultural Chemist at the Poona Agricultural College from August 13th to November 22nd, 1908.

2. The several subjects which are under investigation may be conveniently referred to as follows :—

3. *Meteorology.*—The usual meteorological records are kept by this section and forwarded monthly to the Imperial Meteorological Department.

4. *Rainfall.*—A self-registering rain gauge was fitted up at Pusa and used during the monsoon of 1907 in order to obtain some information regarding the rainfall per unit of time. This is wanted in connection with the estimates of the amount of rain water which runs off the land during heavy rains. The instrument was one which was fitted up by the Imperial Agricultural Chemist locally, and yielded only approximate data, and a more exact instrument will be necessary; but such data as were obtained show the heaviest falls during the monsoon of 1907 to be under 2″ per hour. The monsoon was, however, a very weak one and included only one really large fall.

5. *Evaporation.*—An evaporimeter has been experimented with in order to determine the amount of water which evaporates from free surfaces of water. The results so far have not been very satisfactory.

6. *Drainage.*—Records from all the four drain gauges were maintained. In the monsoon of 1907, these differed only markedly in the amount of surface drainage which was greater from No. 1 than from the others. Nevertheless the No. 1 gauge probably yields the most reliable data. Nos. 2 and 4 had grass on them and were expected on this account to behave differently from Nos. 1 and 3. The rainfall was sufficiently heavy on two occasions to cause an overflow from the pipe fixed at a nominal 2″ above the ground level, and the amounts that ran off were 0·5″ during a 4″ rainfall and 3·5″ during a 7″ rainfall. The amount of water which percolated was 7·5″. The rainfall was 40·3″ during the year (October 1906 to September 1907), and the amount which evaporated during the twelve months was accordingly 28·8″. These are the quantities measured from No. 1 gauge.

The data of the drain gauges at the Cawnpore farm and the samples of the drainage water from them, are provided for this section by the courtesy of the Director of Land Records and Agriculture, United Provinces. The four years' data obtained from these gauges, show that the evaporation there amounts to between 14″ and 20″ in extreme cases, and that the average is approximately 17″ per annum. Hence the amount lost from the Pusa soil is considerably greater than at Cawnpore. This result is probably fully explained by the fact (referred to below) that the Cawnpore soil contains less maximum water per cubic foot than the Pusa soil.

Regarding the constituents which are dissolved in the drainage water, the total amount of nitrogen (as nitrate) in the drainage water was 20lb per acre from the bare fallow soil and ·04lb from that growing grass. This year maize is being cultivated on gauges Nos. 2 and 4 in place of grass. The Cawnpore gauge soil which is maintained fallow, continues to yield large amounts of nitrate. This varies, however, a good deal with the rainfall and also with the depth of the gause. Over a series of years these gauges are yielding approximately equal

amounts of nitrate, but it is not all washed out during the same season; up to the present the deep gauges yield large amounts in a very wet year, whilst the shallower ones, although yielding also more in a year of heavy rainfall than in one of small precipitation, fall short of the deep gauges in this respect, and then recover their position in a year of short rainfall. The data are, however, meagre, and in any case the subject is closely related to that of the period when nitrates are principally formed and their subsequent disposition in the soil, a subject which, though understood fairly well for European conditions, is far from being so for Indian soils.

The monsoon of 1908 was such a weak one that practically no drainage was recorded from any of the four gauges. The rainfall this year up to June 30th has been considerably above the average. Up till May 31st, 1909, 5·15″ of rain fell. In June 28·96″ fell. Percolation began in gauges Nos. 3 and 4 (the 3′ gauges) on June 10th, after 12·31″ of rain (reckoning only June rainfall) had fallen. In the 6′ gauges, Nos. 1 and 2, percolation began on the 11th and 12th June respectively.

Much trouble is caused by the burrowings of various insects into the gauges, and probably largely from this cause gauge No. 2 (a 6′ gauge) has leaked considerably, and part of the drainage water from this gauge has had to be ignored.

7. *Loss of Water from Soil.*—The data relating to the first year's records of the amount of water in the soil at Pusa during the dry season 1906-07, and the deductions made therefrom, have been published as a memoir, No. 6, chemical series. The views put forward in that memoir have been supported by further experiments in the field, the results of which are about to be published.

In order to gain experience of other soils, similar records have been kept at the Cawnpore Agricultural Station, and through the courtesy of Mr. C. Rudston Brown, at Bhatowlia Indigo Factory in Behar, in addition

to another series at Pusa, determinations of the amount of water present in the soil having been made monthly throughout the dry season 1907-08. The latter season was unusually dry at Pusa, so that the soil here was desiccated to a greater extent than generally happens. After reviewing the data of the two seasons, it was found that too much weight had been placed on the effect of atmospheric humidity in the first method of calculating the rate of loss, and that the latter can be accounted for by the effect of temperature in addition to the special characteristics of the soil. The calculated values agree very closely with those found. The data for the Cawnpore soil show it to possess a marked difference from the Pusa soil in the amount of water present at the conclusion of the monsoon, for this quantity is only about 16lb per cubic foot, whereas the Pusa soil contains about 25lb. Moreover, during the season it lost water only to a depth of three feet as against seven feet at Pusa.

The soil at Bhatowlia was selected, because it is a coarse sand for more than 10 feet. This soil only contained about 5lb water per cubic foot at the conclusion of the monsoon.

8. *Water Required by Plants.*—An investigation of the amount of water transpired by plants, was commenced in 1907 by the pot-culture method. In the following cold weather one field experiment was made in conjunction with the latter, and it was found to yield data in close correspondence with those obtained from the pot-cultures. During the last year the pot-culture investigation was extended so as to include (*a*) a larger variety of crops and (*b*) a number of essentially different soils, and in conjunction with this a series of field experiments with various crops was carried out. The data which have been obtained have been put together in a memoir which will shortly be published under the title of "The Water Requirements of Crops in India."

9. *Available Plant Food in Soils.*—This investigation continues to occupy a part of the time of the section, but

is much more complicated than some of the other works. The phosphates form the chief objective, because of the importance which the more perfect valuation of this group of constituents in soils would possess. The only area in which field experiments have been made up to the present in conjunction with the laboratory work, is in Behar. The soil of a large part of Behar is, so far as one can tell from laboratory tests, greatly deficient in readily assimilable phosphates, and field trials were made during the monsoon of 1907 and the following cold weather. The former yielded doubtful results, but the latter yielded, with one exception, considerable increases due to superphosphate.

10. *Soil Gases.*—Closely allied to the study of the assimilable plant food in soils, is probably a more perfect knowledge of the nature of the gases in soils and their quantity. Such information as we possess regarding this subject is but meagre, and since the Indo-Gangetic alluvium offers an exceptionally suitable material for the work, an investigation in this subject was commenced. The results obtained have been embodied in a memoir entitled "The System Water, Calcium Carbonate, Carbonic Acid."

11. *Black Cotton Soil.*—An investigation into the nature of constituent or constituents of this soil which occasion its peculiar colour, was undertaken by Mr. Annett, Supernumerary Chemist. The results obtained from this investigation are about to be published.

12. *Other Investigations.*—Chief among these is a determination of how the composition of the various crops grown on the permanent experiment plots at Pusa, varies with different systems of manuring.

In conjunction with the Imperial Entomologist, some work has been done with the object of freeing stored wheat grain from weevil.

13. *General Analytical Work.*—The number of samples of agricultural materials which are sent by the provincial departments for general analysis, is now practically *nil.* The chief calls on the laboratory for this purpose

are made by Native States, the Irrigation Department and private persons. The number of such specimens examined is about $\frac{1}{5}$th of what it formerly was. This section of the work is now nominal and does not seriously interfere with other work.

14. *Students.*—Three students, two from the Punjab and one from Eastern Bengal and Assam, attended for a course in general chemistry from October 1908 till March 1909. These were all students taking the general course in agriculture. In June 1909, one student came to be trained as Analytical Assistant to the Agricultural Chemist of Bengal.

15. *Establishment.*—Mr. J. N. Sen, M.A., senior laboratory assistant, was, on the opening of the College in July 1908, appointed teaching assistant. Mr. D. B. Darab Sett, B.Sc., resigned his appointment to take up the post of Senior Assistant to the Agricultural Chemist, Burma. Mr. S. C. Kar took his M.A. degree at Calcutta University. Mr. D. N. Chatterjee, B.A., B.Sc., and Mr. C. S. Rama Aiyer, B.A., were appointed Junior Assistants. All the establishment have worked well and given great satisfaction.

16. *Programme for 1909-10.*—The programme of work for the coming year is chiefly a continuation of that described in the foregoing report which may be briefly summarised as follows :—

(*1*) Maintenance of drainage records.
(*2*) Determination of the rate at which water is lost by soils.
(*3*) Ascertainment of the water requirements of plants.
(*4*) Investigation of the work on the availability of plant food in soils.
(*5*) Investigation of the nature of the dark colour of black cotton soil.

The investigation of nitrification in Indian soils will be taken up if possible.

The effect of soil or manure on the composition of certain seeds is an investigation which has been in progress tentatively and will be extended if considered desirable.

The prevention of weevil attacks on wheat is an investigation which is being conducted in collaboration with the Imperial Entomologist.

Instruction will be given to students on the lines indicated in the Pusa syllabus.

REPORT OF THE IMPERIAL ENTOMOLOGIST FOR THE YEARS 1907-09.

(H. Maxwell-Lefroy, M.A., F.E.S., F.Z.S.)

Training.—Students from the agricultural departments of the Punjab, Baroda, Bombay and Eastern Bengal and Assam were fully trained during 1907-09. As this is the first year, the full course of training was given under proper conditions. A considerable proportion of time was given to it, and the lecturing from October 1908 to April 1909 done by the Imperial Entomologist. The organisation and carrying out of this course has been the most important work of the last two years, and it is to be regretted that so few students took advantage of it. A short training, as part of the course in general agriculture, was given to two students from the Punjab and to a fieldman of the Fibre Expert, Eastern Bengal and Assam. Students from the United Provinces, Madras and Bengal arrived in June 1909.

2. *Establishment.*—The assistant for sericulture, Mr. L. M. Dass, was recently appointed; there have been no important changes. The First Assistant, Mr. C. S. Misra, has had direct charge of students, of the field work on the Pusa farm and the work with lac. Apart from the courses of lecturing given personally by the Imperial Entomologist, Mr. Misra has had charge of the practical and field work of students, which he has done in an admirable manner. He also visited Sind in reference to the boll-worm on cotton. The Second Assistant, Mr. C. C. Ghosh, has had charge of the insectary and has had very heavy additional work in connection with *eri*-silk, of which he will now be relieved. His work has been of great value. The Third Assistant, Mr. G. R. Dutt, has been in charge of economic records and collections, and has done

original work on aculeate hymenoptera. The assistant in charge of the collections, Mr. D. Nowrojee, has done excellent work with the arrangement and upkeep of the general insect collections which are now permanently stored in a proper manner. The Bengal assistant worked in the laboratory, as there is no proper accommodation for him as yet at Sabour, and with the Second Assistant, Mr. C. C. Ghosh, prepared the revision in Bengali of *Indian Insect Pests*, in addition to his ordinary work. The staff of the Second Imperial Entomologist worked under the guidance of the Imperial Entomologist until the arrival of this officer, and the artist's staff of the Institute also worked under him till March 1908.

3. *Buildings.*—The section moved into the permanent laboratory during May 1908. The section is now established in permanent quarters in the laboratory; the insectary, silkworm house and a godown are also being occupied.

4. *Provincial Work.*—The number of assistants employed in entomological work in the provincial agricultural departments is now 13, for teaching, demonstrating and field work. This number is inadequate to bring the practical work of entomology effectively before the agricultural classes, but a beginning is being made with practical teaching of entomology at the provincial agricultural colleges and also with demonstrations at shows. In March last, a meeting of the assistants was held at Pusa to discuss progress, to demonstrate improvements, to show the work in silk and lac, to teach how to put up show-cases for exhibitions and to arrange how best effective assistance could be given from Pusa, especially with regard to shows and demonstrations. The work of provincial assistants is under general direction from Pusa, in the sense that their monthly reports and programmes are sent here for criticism; assistance is given in preparing their programmes in all technical matters such as identifications, supply of apparatus, books, etc., and in the teaching given

at the college. There is no uniform system for all provinces, and the relations are closer in some cases than others, but all assistants can obtain the effective assistance of this section, where it can be given. Progress has been made in the general study of injurious insects in the provinces, notably in Madras, where a careful study has been made of the *surul* pest of groundnut, of paddy stem-borers and of the general pests of the province. In Bombay, an enquiry was made into the occurrence of the potato moth. In the Central Provinces, Bengal, Eastern Bengal and Assam and the Punjab, the general investigation of injurious insects has been continued, and in the last named province the progress of cotton boll-worm and its parasites has been closely watched. A general strengthening of the staff is required in most provinces.

5. *Correspondence.*—As in previous years, there has been a large volume of enquiries on all matters connected with insects; the enquiries directly connected with insects injurious to crops, have been in part diverted to provincial departments, but a large mass of miscellaneous enquiries has been received and dealt with. Excluding correspondence with provincial agricultural departments, these are received from commercial firms, planters and planters' associations, zemindars, fruit-growers, superintendents of experimental farms and botanical gardens; specimens sent for report by the members of the Bombay Natural History Society, are, in some cases, forwarded and dealt with here, and there is a certain number of enquiries from persons interested in entomology for the identification of specimens. The increasing interest in silk, lac and bee-keeping also produced a large number of enquiries. Over one thousand of such enquiries were dealt with by the Imperial Entomologist personally during the last two years, and this work is, by no means, the least useful part of this section's activities.

6. *Research.*—Progress is steadily made with enquiry into the life-histories and habits of injurious insects. The

more important have been the cotton boll-worm, the potato moth, two cockchafer beetles, the mango leaf hopper, the *mohwa* beetle, the *singhara* beetle, the bristle beetle, the surface grass-hoppers, the big cricket, the rice and cane hispas, the sweet potato weevil, the *til* hawk moth, the Behar hairy caterpillar, the *tur* pod bug, the cane leaf hopper, the armyworm of rice, the rice stem-borer, the melon weevil, the rice and cane mealy bugs, the rice leaf hopper and the pests of castor, rice and indigo. The influence of climatic changes upon insect life and the problem of utilizing beneficial insects, have also been investigated. The search for an insecticide less poisonous than arsenic was continued and brought to a conclusion, the field trials showing that the new insecticide is extremely effective. An enquiry into the best method of checking thrips on tea in Darjeeling was taken up by arrangement with the Scientific Officer of the Indian Tea Association and spraying trials made; the method tried was found satisfactory and is in use at present. In connection with potato moth, the trial of methods of seed potato storage was made, and this work is being carried on in collaboration with the Central Provinces Agricultural Department. Trials are being made in the Central Provinces and also in Bengal. The relation of the wheat weevil to the percentage humidity of wheat is being investigated in collaboration with the Imperial Agricultural Chemist, for the Department of Commerce and Industry. Cantharides or blister beetles are a pest in India, and an endeavour is being made to ascertain if they are of commercial value, so that those who suffer from them, may derive profit from collecting them. The enquiry into the food of birds was continued by Mr. Mason, as also investigation of methods of fumigating plants, grain, etc. The question of taking steps to check the promiscuous introduction of noxious insects from other countries, was under consideration, and recommendations were made for dealing with plant imports. Mr. Mason visited the centres at which the army stores are baled and stored to investigate the occurrence in clothing, etc., of the

destructive insect *Anthrenus vorax;* this enquiry was completed and recommendations made for better baling. The question of apiculture was taken up to determine how far bees will thrive in the plains, and whether apiculture can be carried on sufficiently well here to enable it to be a subject for demonstration and teaching; this work is in progress.

7. *Sericulture.*—The cultivation of *eri*-silk was continued, and the process of spinning, dyeing and weaving taken up. This is carried on as a demonstration to students of the value of this silk as a home industry in India, and to enable any one who wishes to start it, to be taught the work practically. A practical spinning machine of a simple kind was devised by Mr. Ghosh which is now in use; it is being improved, and its value is being thoroughly tested. During the meeting of the assistants in March last, the work was taught to them, so that they could, if opportunity arose, give advice. The Superintendent of Sericulture of the Baroda Government also came, as this silk has been introduced in Gujarat. The publication of an article in the *Agricultural Journal of India*, the exhibition at the Muzafferpur show and the work of the Baroda Agricultural Department, have drawn attention to the possibilities of this silk; it is being taken up in Tirhoot, Gujarat and elsewhere, and enquiries about it have been received from every province; eggs have been supplied free, or at a small price, to all who have asked for them, and the work has been shown to many enquirers. It is probable that this silk will be taken up in many parts of India, and that an industry will spring up, similar to that existing in Assam, which will give light remunerative work to women and children. Arrangements were made to supply cocoons for spinning as a famine relief work for *purdah* women in one district, and the work is being organised in some Tirhoot indigo concerns. It may be noted that the staff for this work consists of one assistant newly appointed, a fieldman and the coolies actually doing the work in

the silkworm house; to properly develop this industry would require a staff available for temporary service in tracts where conditions are favourable; the only men available for demonstrating in outside places are trained coolies, and there is room here for an increase of staff; so far as possible, requests for assistance are met from the available staff. As the purely experimental work on *eri*-silk is almost completed, the cultivation of mulberry silk has been taken up; the main object is to determine how far it is possible to grow mulberry silk profitably, to supply the raw material which is imported at present and to supplement the supply of raw silk produced at present in Lower Bengal, to see whether improvements can be effected and to provide instruction in rearing and reeling if the prospects are favourable.

The question of *tussar* silk is also being investigated, besause in this, as in other silks, advice is asked on points which can be determined only by entomological, as apart from purely sericultural, enquiry.

8. *Lac.*—The cultivation of lac insect on *ber* (*Zizyphus jujuba*) has been continued, and progress made in extending the cultivation in Tirhoot. Seed has been supplied, and men trained for twelve indigo concerns in Tirhoot, and advice given about the cultivation of lac to many enquirer. Lac inoculation was done for the Public Works Department of Bengal in connection with canals, and assistance given to the Bikanir State in regard to the possibilities of lac culture there. The cultivation of lac as an adjunct to ordinary cultivation has been explained in an article for the *Agricultural Journal of India*, volume IV, part 3, and it is solely from that aspect that it is being done. The work of assisting the cultivation of lac will probably expand. Training in lac cultivation is given at Pusa at the present time, and advice given to enquirers.

9. *Insect Survey.*—The general collection of insects of India, apart from the purely economic one, has been transferred to its permanent quarters and is completely

arranged and catalogued. Mr. C. W. Mason has arranged the Lepidoptera, the Assistant to the Second Imperial Entomologist the Coleoptera. A large part has been sent to England for the use of authors of prospective volumes of the fauna of India; the Orthoptera, Neuroptera, Braconidæ and Ichneumonidæ, Cetoniidæ Chrysomelidæ, Curculionidæ, Microlepidoptera and Rhynchota Homoptera are the larger collections being worked at in this way. A large part has been returned, and the whole collection is yearly becoming more complete and useful. The greatest help was given by the late Colonel Bingham, and by his death we have lost an able collaborator who gave invaluable assistance to all who are interested in Indian entomology. We have now a good reference collection as well as a separate collection for students, of the insects of Pusa, both of which are necessities in daily work. In conjunction with the Indian Museum, the results of the past work are being worked up and utilised in determining the zones of insect life in India. Specimens were exchanged with the Indian Museum; a collection of Coleoptera was identified for the Bombay Natural History Society and completed from our duplicates. Similar collections were identified and made up for provincial agricultural colleges, and their collections are sent here for identification and arrangement. A good collection is the basis of accurate work and teaching, so that this work is of importance and can be done from Pusa only. The formation of the collection will be continued, but less time will be devoted to it.

10. *Demonstration.*—A series of excellent coloured plates with short printed explanations, has been issued, which are used for teaching in colleges, are exhibited at demonstration farms and are made up into show-cases for exhibitions and shows. This series will be continued and is being expanded also to cover silk, lac, bees and beneficial insects. As the work of the provincial departments expands, this work will also expand; and, since only simple methods of checking pests can be used, the teaching of the people and the demonstration of simple facts and remedies

will become an important part of the work. In all provinces, teaching at colleges, enquiry into local pests and demonstrations both of facts about insect life and remedies for pests, are now going on.

In February last an exhibit of injurious insects, lac and *eri*-silk was sent to the Muzafferpur agri-horticultural show. Increasing attention is being paid to this in provincial departments and the best methods of preparing such exhibits are being tested here; a complete exhibit in show-cases has been prepared as a model, and it is proposed to send exhibits to shows or to assist in this work to gain experience as to the class of exhibits that most appeal to the public. Show-cases of injurious insects, silk, lac, etc., with specimens, plates and explanations in the necessary languages, have been prepared for some provinces and will be prepared by the entomological assistants in others; and, as an aid to these, series of lantern slides in colour are being prepared in order that lantern lectures may be given at such shows. This work will be an additional tax on the time both of this section and of the provincial assistants, but it falls chiefly at one season and is an extremely important work.

11. *Publications.*—The marked influence of *Indian Insect Pests* is noticeable, and its publication in 1906 has been abundantly justified. A simplified revision in Bengali has been prepared and proposals submitted for its publication. Other vernacular revisions will follow as provincial work expands sufficiently to make them possible.

A text book on "Indian Insect Life" has been issued in July last. The issue of this volume of over 800 pages with over 500 half-tone illustrations and 85 coloured plates has entailed very heavy work which has fallen entirely upon the Imperial Entomologist. The publication of the volume completes the preparations for proper teaching and marks the close of the period of preparation of the past six years. The series of memoirs on injurious insects were continued, and popular articles on those of great importance

written for the *Agricultural Journal of India*. The influence of the latter is shown by the immediate increase in correspondence from the public in India after the publication of an article on a particular subject.

12. *Conclusion.*—As this is the only entomological centre in India, the section is so fully occupied in the immediately practical work of answering enquiries, assisting provincial departments, facilitating the teaching of agricultural entomology and assisting in the establishment of insect industries, that there is no time to apply research to subjects not of immediate necessity and this must be so until the staffs of the provincial departments expand. Research, as ordinarily understood, is done here only so far as will enable a practical answer to be given in each definite practical case. The progress that has been made in all branches of the subject and its great practical importance justify an expansion of the staff both at Pusa and in the provinces. To practically apply the results gained and to continue the progress which has been made possible from the research and enquiry of the past, require a constant expansion especially in provincial departments setting Pusa free to continue the work of enquiry.

13. *Programme for 1909-10.*—The work of the past in studying and advising on crop pests will be continued. Assistance will be given, when desired, in directing the work of provincial assistants, in coping with outbreaks of crop pests and in organising exhibitions for agricultural and other shows. The issue of coloured plates will be continued. Enquiries in progress on potato moth, fumigation of plant imports and grain and on wheat weevil will be continued. Advanced teaching in entomology will be continued. The question of publishing vernacular translations of the revised text of *Indian Insect Pests* will be considered. The possibilities of apiculture in the plains will be tested at Pusa. A short practical course of instruction in *eri*-silk and in lac culture will be given if required. Mulberry silk culture will be continued with a view to

offering instruction in rearing and simple methods of reeling. If possible, the question of producing better races will be taken up experimentally, but this may not be possible if the practical courses of teaching occupy much time.

REPORT OF THE SECOND IMPERIAL ENTOMOLOGIST FOR THE YEARS 1907-09.

(F. M. Howlett, B.A., F.E.S.)

1. *Charge and Establishment.*—Mr. Howlett arrived at Pusa in December 1907 and has been in charge of the section since. The staff consists of Mr. D. Nowrojee, First Assistant, with Messrs. P. G. Patel and H. N. Sharma, special Fly Assistants. Of these, Mr. Nowrojee carries on his previous work on Coleoptera, and Mr. Muhabat Singh has been detailed in his stead for work on the flies affecting crops and fruit. Mr. P. G. Patel has made a number of original observations on ticks, sand flies and muscidæ, and has had charge of the general collection; Mr. H. N. Sharma has been occupied with the life-histories of mosquitos and investigation of their natural enemies. All have done good work in their particular branches.

2. *Training.*—Since diptera constitute a special group of insects requiring special methods and careful manipulation, a considerable amount of attention has been given to the instruction of the staff in these methods. Mr. P. G. Patel was sent to Belgachia, at the request of the Civil Veterinary Department, Bengal, to give a course of instruction relating to biting flies injurious to cattle. Messrs. P. N. Das and Syed Mohomed Raza Husain, of the civil veterinary departments of Bengal and the United Provinces, respectively, came to Pusa for a course of training in methods of observing and collecting pests and parasites of cattle and other stock. As a part of the course given to agricultural students in entomology, lectures were given on diptera and on blood-sucking insects, special attention being paid to fruit flies and cattle parasites. A short series of lectures on more purely economic lines was given to the provincial entomological assistants

on the occasion of their last visit to Pusa. Mr. Chimaswami Pillai, sent by the Madras Government for instruction in methods of illustrating, finished his course and returned to Madras.

3. *Work on Publications.*—That portion of the book, "Indian Insect Life," which relates to diptera and the sections on mallophaga, anoplura and cimicidæ, was completed, and the necessary illustrations prepared by the Second Imperial Entomologist or under his supervision, as were also a large number of the illustrations for the body of the work and other illustrations and maps required for memoirs and for the *Agricultural Journal of India.*

The business of seeing the *Agricultural Journal of India* through the press, and all work connected with the reproduction, etc., of the illustrations in zinco, half-tone, lithography and the three colour process, was also undertaken.

In February last the Second Imperial Entomologist acted as Secretary to the Board of Agriculture at the Nagpur meeting and prepared for publication the proceedings of the meeting.

The supervision and direction of the artists' staff of the Institute have been undertaken, and besides the work done for the various sections at Pusa, assistance has been given to the civil veterinary departments and to the Bombay Natural History Society in preparation of special illustrations of blood-sucking flies and of living snakes.

4. *Entomological Work.*—Work was done on the rice, *tur* pod and pea-stem flies. The first named was found to be doing serious damage to wheat (planted after rice) in Sibi, Baluchistan, and Mr. Muhabat Singh was sent to investigate and report on the outbreak. Work was done in fruit flies, and an attempt to check the annual attack of these pests on the peaches grown at Pusa, was this year so far successful that the period of severity was postponed until the Imperial Economic Botanist was enabled to complete the experiments in progress. It is unlikely that

any method short of netting, will have any radical effect on the flies under the conditions at Pusa. Methods for destroying the mango fly (the most destructive species in Behar) have been tested with success. Mr. Froggatt, Entomologist to the Government of New South Wales, visited Pusa in June 1908 for the purpose of obtaining information on the subject of fruit flies, as the Australian fruit flies are related to those found in India and constitute a very serious obstacle to the successful cultivation of fruit there. Since his return he has been supplied with fruit flies specimens for the purpose of assisting his investigation on the Australian species. Arrangements have been made with Professor Silvestri to supply parasites of some of the south Indian species in the hope that they may be utilised against the olive fruit fly, a species which inflicts great damage in Italy.

Among blood-sucking flies attention has been directed chiefly to the life-histories of sand flies, tabanidæ and muscidæ, and the Pusa species are now fairly well-known. A number of specimens have been received from various parts of India, from the officers of the civil veterinary departments and from medical men. A report on 800 specimens received from Bengal was communicated to Mr. D. Quinlan, Superintendent, Civil Veterinary Department, Bengal, and data as to the distribution of the various species are thus being obtained.

A number of specimens have been identified for medical men and for private individuals, and various enquiries regarding blood-suckers, parasites, infective and predaceous insects, have been received and answered. A report on the value of certain insecticides advertised as being efficacious against various parasites, has been supplied to the Inspector-General of Agriculture in India. Arrangements are in progress for supplying Indian blood-suckers to the Sleeping Sickness Commission in Uganda for the purpose of testing the possibility of sleeping sickness being transmitted by any Indian species as well as by the tsetse fly.

The life-histories of nearly all the mosquitos which occur in Pusa have now been ascertained, and a special study has been made to discover any efficient natural checks on their increase. Two species of fish have been found to be capable of destroying large numbers of anopheles larvæ, while a small water insect seems not unlikely to prove a useful check on culex; experiments on a large scale have not yet been tried.

Observations on the life-history and habits of ticks have been made, and experiments on the best means of destroying them.

Some attempts have been made to discover the effect of various physical conditions on mosquitos and other blood-sucking insects, but, though some minor results of interest have been obtained, this very important line of research demands more time than the Second Imperial Entomologist has been able to give.

A considerable number of specimens have been lent to the Indian Museum in order to assist in the revision of the nomenclature of various groups of Indian diptera, and a large representative collection of tabanidæ has been lent to the British Museum to assist in like manner the revision of the family now in progress.

In January last a number of specimens, drawings and photographs of various blood-sucking species, were contributed to an exhibition of disease-carrying insects organised by Dr. Annandale at the Indian Museum.

In February last an exhibition of all kinds of blood-sucking and parasitic insects was arranged for the pathological section of the Bombay Medical Congress; a few slides and specimens were lent for incorporation with other exhibits; a simplified key to the different kinds of blood-sucking insects, was written for the use of visitors to the exhibition; a paper on the habit of sand flies was read before the pathological section; and a public lecture on blood-sucking insects delivered. The Second Imperial Entomologist derived much pleasure and benefit from the

opportunity of meeting and conversing with medical men from all parts of India.

5. *Correspondence.*—A considerable amount of correspondence has been involved in the investigation on biting flies. Sets of apparatus and copies of the bulletin on biting flies have been issued to the Directors of Agriculture, Punjab and Bengal, the Assistant to the Chief Commissioner, Baluchistan, the Assistant Political Agent, Khelat, the Honourable the Agent to the Governor-General, Quetta, His Britannic Majesty's Consul, Seistan, the Honorary Secretary, Baluchistan Natural History Society, the superintendents, civil veterinary departments, Bengal and Eastern Bengal and Assam, the officer investigating camel diseases, the officers of the Indian Medical Service and Royal Army Medical Corps, and private individuals in all parts of India, and it is anticipated that the material thus obtained will greatly assist the enquiry.

Correspondence on matters connected with the working out and identification of the collections, has been carried on with experts in Europe and America and on various scientific subjects with the bacteriological laboratory at Parel, the Indian Museum, the Bombay Natural History Society, etc., and with various private individuals.

6. *Conclusion.*—The necessity of devoting a considerable amount of time to the illustrating and publication work of the Institute naturally restricts, to some degree, the work connected with pure entomology. During the past year the illustrating work had at times been particularly heavy. A further restriction is due to the fact that no laboratory accommodation was originally provided for this section, with the result that all work has to be carried on in a single room which perforce serves the purposes of office, laboratory, store-room, collecting room and insectary. The very important work on life-histories of insects in particular has suffered for lack of a suitable place for carrying on breeding operations, and there is no accommodation whatever for students.

The number of enquiries received is considerable and is expanding, but without further accommodation it will be impossible to cope with the expansion.

7. *Programme for 1909-10.*—Work on blood-sucking insects and parasites injurious to cattle and poultry will continue, and arrangements have been made for an investigation, in collaboration with Mr. Leese, Veterinary Officer investigating camel diseases, Lahore, on insects capable of transmitting *surra*.

Trials will be made of the relative value as checks of the various natural enemies of mosquitos discovered at Pusa, and to ascertain whether the introduction of Indian fish is likely to prove of practical value in eradicating *anopheles* in places where other measures are impracticable or difficult.

A short course of lectures on pests of live-stock and poultry for agricultural students, is being drawn up in collaboration with the Imperial Agriculturist, and all necessary assistance will be given in carrying out the ordinary course for students at Pusa.

Attention will chiefly be directed to the dipterous pests of crops and fruit and to the study of the tachinid parasites of insects found at Pusa. The collection of diptera will be as far as possible worked out from the systematic point of view.

The publication work and the control and supervision of the artist's staff will continue as hitherto, unless other arrangements are made for the allotment of the duties in connection with this branch.

REPORT OF THE IMPERIAL MYCOLOGIST FOR THE YEARS 1907-09.

(E. J. Butler, M.B., F.L.S., and W. McRae,, M.A., B.Sc.)

1. *Charge and Establishment.*—The Imperial Mycologist held charge of his section till the 31st March 1909, when he proceeded on combined leave, and Mr. W. McRae, who had joined his appointment as Supernumerary Mycologist in March 1908, after a period of six months on deputation in the laboratory of Professor von Tubeuf at Munich, was appointed to officiate in his absence. The first assistant, Mr. S. K. Basu, resigned his appointment with effect from 16th December 1908. The post is not yet filled up. The appointment on probation of Mr. T. S. Lakshman Rao as assistant to the Supernumerary Mycologist, terminated on 31st March 1909, when Mr. A. Hafiz Khan, second fieldman, was promoted to the post. L. S. Subramanium, clerk on probation, was appointed third fieldman.

2. *Laboratory.*—The section moved into the new laboratories of the Phipps' Institute in June 1908. In the temporary quarters previously occupied, the work was much interfered with by dirt and insects, and the move has given much needed relief from these. When some minor improvements are carried out, the section will be well-housed in its new quarters.

3. *Training.*—A mycological assistant for the United Provinces was under training until September 1907. Another for Bombay joined in June 1908, and the Assistant Professor of Botany, Poona Agricultural College, received a short course in April and May 1908. A mycological assistant for Madras joined in November 1908, and the Mycological Collector for Eastern Bengal and Assam joined in September 1908. A student from the Central Provinces received a course in cryptogamic

botany from July to September of last year, and again in plant anatomy from November to February. Two students from the Punjab undergoing a general course in agriculture, joined on the 1st June, 1909. The Assistant Mycologist, Bengal, who returned to Pusa in March, 1908, has remained in this laboratory pending the provision of accommodation for him at Bhagalpore. The prospects of assistants in the agricultural departments appear to have been hitherto insufficient to attract good men.

4. *Organisation.*—Much time has still to be given to organising the work particularly to meet the requirements of provincial departments. Collections have to be accumulated and worked out with what voluntary assistance can be got outside India. Duplicate collections will be, as far as possible, supplied to provincial departments which already have mycological assistants. Annotated specimens of Mildews and of Ascomycetes have been sent to Mr. Salmon of Wye College and to Messrs. H. and P. Sydow of Berlin, respectively, to be worked out for extension of the general survey of Indian parasitic fungi. Collections of diseased plants received from the Central Provinces, Bengal, Bombay, Burma and Madras, have been worked out and returned, and these will be gradually extended, as further material becomes available.

In the provinces, the question of the best means of expanding mycological work was considered by the Board of Agriculture which sat at Pusa in February, 1908. A small special staff of Indian assistants to be formed in each provincial department was recommended, their duties being defined as assisting the research work of the Pusa staff and conducting the training at the colleges. The ordinary staff of agricultural assistants should undertake such practical field work in preventing diseases as is necessary. In each province there will probably be appointed one assistant professor of mycology at the college and one assistant for work outside the central station. This will form a beginning which can be extended ultimately.

Arrangements have been made for unifying the proposed mycological course in the provincial colleges, and a memorandum on a course of lectures and practical work together with the most important diseases, has been compiled as a basis for this unification of mycological teaching.

5. *Research Work.*—A small number of diseases have been selected for detailed study which, in some cases, has continued over several years. The life-history and general biology of the parasites have been studied, and information obtained of their effects on the attacked plants. The following are the chief diseases specially investigated :—

6. *Sugarcane Diseases.*—Red rot is the chief of these. The work of the period under report has been directed to elucidating the methods of infection. It has given some new results, and it is hoped to publish a further contribution to the study of this disease during the year. In the Samalkota farm red rot is now quite rare in the crop, and this may be considered due to the methods of set selection advocated by this section. Work is in progress on the life-history of two other sugarcane parasites, but so far has not reached the publication stage. A few inoculations to ascertain the mode of infection of smut proved successful and these experiments are being continued this season.

7. *Palm Diseases.*—The campaign against the palm disease of the Godaveri delta is still being prosecuted, and the entertainment of the special staff employed has been recommended for a third year. The Imperial Mycologist inspected the work in September and December 1907 and in January 1909. There has been no general recrudescence of the disease in the early months of this year, such as occurred last year, and the Imperial Mycologist was struck by the very small number of newly diseased trees seen in his tour in January last. Under the new system inaugurated in October 1908, it is hoped that cutting work will go on continuously and simultaneously over the whole of

the affected area. Successful inoculations with the parasite have been secured, and a further study of its life-history made.

A serious disease of cocoanut palms was reported from Travancore early in 1907, and the Imperial Mycologist visited the State in September and October of that year to investigate its cause. A report on the disease has since been published.

8. *Diseases of Citrus Fruits.*—The chief of these investigated were "white rust" which has appeared at Poona, and a disease which is ravaging the valuable orange orchards of Sylhet and Lower Burma. The former is identical with a disease which has recently appeared in Southern Europe. Suggestions for experimental treatment have been made. The other disease does not appear to have been previously recorded. The Imperial Mycologist visited Burma in January 1908 to investigate it, and experiments are in progress to ascertain its cause. It appears certain that it can be avoided by grafting on stalks of other citrus plants.

9. *Wilt Diseases.*—These diseases have engaged more attention during the period under report than any others. Out of the considerable number, all similar in their course, which affect economic plants in India, those of cotton, indigo, pigeon-pea and gram were selected for study. In all, the fungus to which the cotton wilt of the United States is attributed was present, and the assumption was that this fungus which is said to be a virulent parasite in America, was the responsible agent in each case. Detailed experimental work has, however, thrown the gravest doubt on the parasitism of this species, and another organism was isolated from pigeon-pea which has been shown to be the cause of the disease in this crop. This organism has been called *Fusarium udum*, Butler. A memoir on the work is now in the press. The cause of the gram wilt disease has also been definitely determined, and successful infections obtained. The investigation has been lengthy and troublesome, but the diseases

referred to are amongst the most destructive in India and will well repay study. The experiments at Poona farm to raise a resistant strain of pigeon-pea, have been in progress four years and are promising well.

10. *Mulberry Disease of Kashmir.*—In a visit to Kashmir during the months of July, August and September, 1908, the Imperial Mycologist enquired into the diseases of mulberry and also those of apple, pear, peach, quince, cherry, apricot and grapevine. The results of part of this work have been published, and recommendations made for dealing with mulberry diseases. The study of the other diseases is in progress. A large collection of fungi was also made for the herbarium and these are being gradually worked out in the laboratory.

11. *Ginger Disease.*—This disease causing considerable damage in Eastern Bengal was investigated, and the probable cause of the disease determined. Experiments are still being carried out with the disease.

12. *Other Diseases of Plants.*—A new anthracnose of *val* (*Dolichos lablab*), some species of the rare genus, Choanephora, and the two maize smuts of India, have been studied, and a successful attempt has been made to work out the life-history of the very obscure paddy smut. As usual a large number of other diseases of crops were examined, and this work has formed a large portion of the routine work of the staff.

13. *Silkworm Disease.*—At the instance of the Imperial Entomologist an attempt was made to ascertain the cause of the heavy mortality amongst *eri*-silkworms during the hot weather of 1908 at Pusa. The mortality appears to be due to a specific disease allied to, but not identical with, that known as "flacherie" in ordinary silkworm.

14. *Programme for 1909-10.*—It is proposed to continue the work with sugarcane diseases and to publish a further contribution to our knowledge of red rot. If sanctioned by the Government of Madras, the palm disease campaign in the Godaveri delta will be continued. An account of

the parasite and a review of the work undertaken to prevent its spread will be published shortly.

It is hoped to complete during the year an illustrated account of the chief diseases of citrus fruit trees in India with suggestions for treatment.

It is proposed to continue the work on the wilt disease of leguminous crops, specially cow-pea, to determine the exact cause of the disease in each case.

The collection and identification of parasitic fungi will be continued. It is hoped to secure the publication of a complete list of the species of Ascomycetes in the Pusa herbarium.

It is hoped to complete the text of the book on Indian plant diseases during the year.

Students will be received for training, the regular course of instruction commencing on June 1st.

REPORT OF THE IMPERIAL COTTON SPECIALIST FOR THE YEARS 1907-09.

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

1. *Charge.*—Mr. Gammie joined the Imperial Department of Agriculture as Imperial Cotton Specialist on the 14th December, 1907, and has continued in charge of his office since. Until 10th October, 1908, when he was relieved by Mr. W. Burns, he held charge of the office of Economic Botanist, Bombay, in addition to his own duties, and from 6th August to 30th September, 1908, he held charge of the office of the Principal, College of Agriculture, Poona, owing to the illness of the Principal and the Professor of Agriculture.

2. *Tours.*—During the cold weather of 1907-08, the Imperial Cotton Specialist examined the cottons on all the farms of the Bombay Presidency and gave advice. In March 1908, he visited some farms in the Madras Presidency and discussed the experiments in progress with the Deputy Director of the northern division. During April and May an extensive enquiry was made regarding the varieties of cotton and the conditions under which the cotton crop is grown in Gujarat and Kathiawar. In Surat and Broach districts the quality of the cotton is best in the south and gradually gets worse as one proceeds northwards. Navasari has the finest and longest staple, then comes Surat and then Broach. This may be due to the heavier rainfall and greater atmospheric humidity at Navasari (owing to its proximity to the sea), for there is little apparent difference in the soil. Cultivators of the neighbouring districts have used Navasari seed, but, although the produce was ginned and despatched to Bombay separately, it failed to realise the same price as that obtained for cotton grown at Navasari. This may, however, have been due in part to the marks on the bales

showing that the cotton came from Broach and Surat. The two cotton varieties *Broach deshi* and *ghoghari* grown in the latter two districts are quite suitable to the tract, but it is absolutely necessary for the cultivators to maintain the purity of the seed. The growing practice of separating seed from the fibre in ginning factories, instead of as formerly by hand gins, has tended to injure the quality by mixing the seed. The average farmer gets his seed haphazard from the general supply at the ginning factory, good, bad, early, late, medium, tall, bushy and ordinary varieties all mixed. There can be no improvement, unless the seed is at least equal to the average of the previous crop. The improvement by selection of seed continued from year to year, is most important. If careful selection of seed is practised, and if the cultivator takes the trouble to handgin his seed at home, there is hope that the lint will be improved in quality and that the outturn per acre will also increase. In selecting the seed, cotton should be picked from the best sound bolls of large, healthy plants of branching habit of growth, each plant having a large number of bolls. Of the two varieties now growing in these districts the *Broach deshi* variety is the *standard*, and at present its price in the Bombay market rules that of all other cottons of India.

Kathiawar accounts for more than one-third of the total area under cotton in the Bombay Presidency (excluding Sind). Formerly *wagad* and *lalio*, two varieties of nearly the same quality as *Broach* (though picked less carefully, and, on that account, fetching a lower price), were the only ones found in Kathiawar, but on account of the succession of years of irregular rainfall, beginning with the famine year of 1900, they have been largely replaced by two inferior coarse varieties *mathio* and *navesari* (not Navasari) from Central India which give good yields, mature early and can be grown without much risk in years of scanty rainfall.

During the month of October, 1908, the Cotton Specialist visited the Punjab, Sind, Rajputana, Central

India and Gujarat. Throughout the four first named, the prevailing cottons are of *neglectum* type mixed with a plant resembling *bani*. If these two cross freely very close observation would be needed to establish the fact; that they remain, on the whole, true to type is easily demonstrated. The produce of these plants is probably the most inferior cotton in India which, however, fetches a price in advance of its intrinsic merits on account of its white colour and suitability for adulteration with wool. Throughout the area is found intermixed a superior style of cotton which has been already distinguished by the Cotton Specialist as *malvensis*. Officers of the provincial departments who are serving in coarse cotton tracts are already testing the feasibility of establishing this as a pure race, and Mr. Clouston of the Central Provinces is sanguine of ultimate success.

In the Punjab alone there is an annual variety of *arboreum* which the Cotton Specialist has already named *sanguineum*. It occurs chiefly as a *mixture* in the fields, and from a trade point of view there is no particular reason why it should be isolated, as its cotton is in no way different from that of the more common varieties. At the Lyallpur farm the Economic Botanist was engaged in studying a set of Punjab cottons, so that he could draw out a scheme for future work in selection. The experiments with upland Georgian and Egyptian cottons were of prime importance. The former is not of the New Orleans type, naturalised in the southern parts of Bombay and Madras, and which is intolerant of cold, but the true Upland which requires a distinct autumn for its development. Sales of this cotton have proved that a good price can be readily obtained for it, and since the officers of the Punjab Department have found in this a product far in advance of anything they can hope to attain from the selection of their indigenous varieties, it was gratifying to see that they were attending specially to the establishment of first class varieties of upland Georgian. They ought in this connection to carefully study the methods

employed in the United States. Of the chance of success for Egyptian cotton in the Punjab there is more doubt. The Bombay merchants consider that the Egyptian cotton grown in Sind is distinctly inferior to that directly imported from Egypt, and that from the Punjab would probably be no better.

In Sind the Cotton Specialist discussed the subject of cotton cultivation with Mr. Henderson, Deputy Director of Agriculture. The latter is of opinion that the very sanguine estimates formed on the results of trial sowings of Egyptian cotton, must be considerably modified in the light of recent results. He states that no further extension of the area suitable for growing Egyptian cotton can be counted on outside the Jamrao canal district until a further system of perennial canals is constructed, and that on the Jamrao canal a maximum of not more than 10,000—20,000 acres could be sown under favourable circumstances. Further, owing to scarcity of labour, occasional scarcity of water and the often alkali condition of the soil, the Jamrao cultivators prefer a surer, if less profitable, return in the cultivation of millets and short stapled indigenous cotton to giving the requisite care to the cultivation of Egyptian cotton. Despite the unsatisfactory results hitherto obtained, Mr. Henderson believes that good results can be got with Egyptian cotton when Egyptian methods of cultivation are closely followed. He lays special stress on very careful cultivation and rotation of the cotton crop with *berseem* (*Trifolium alexandrium*).

The American cottons, Texas Big Boll and Boyd's Prolific and also the acclimatised Dharwar-American, have been tested during the last year in Sind and have given promising results. They have a shorter growing period than Egyptian cotton, enabling them to be sown on inundation canals.

At the sewage farm in Karachi Spence cotton, Egyptian cotton and Sea Island cotton were tried with disappointing results. This was to be expected, as cotton is in no way a suitable crop for a sewage farm.

The Central Indian cottons consist only of *bani*, *jari* and *varadi*, with the usual preponderance of inferior types, and the remarks made on the Central Provinces cottons below will also apply to these.

In November, 1908, the Cotton Specialist visited Bassein in the Konkan to study the results of Bourbon cotton cultivation there, and then proceeded to Pusa to discuss various subjects with the Inspector-General of Agriculture in India and other officers of the Imperial Department. Afterwards a visit was paid to Bhagalpur, and cotton matters were discussed there with Mr. Woodhouse, Bengal Economic Botanist. Cotton is not, of course, an important crop in this Presidency, but the attention of the officers of the department might be drawn to the fact that *Gossypium intermedium* (according to the classification of the Cotton Specialist) is perhaps common as a garden crop in some parts. At least three separate plots were seen between Muzafferpur and Pusa, adjoining the railway. Sir George Watt, in his recent great work, states that the famous Dacca muslins were manufactured from one of the coarsest cottons in India, and he reproduces Roxburgh's coloured figure to support his point. From internal evidence it may be gathered that Sir George Watt was ignorant of the existence of *Gossypium intermedium*, because the picture he gives shows clearly a distinct form of this race. Some varieties in favoured localities may produce fine staple which is far more likely to be used in the manufacture of a superfine cloth than one which closely approaches the coarse Bengal or Assam type. There is no record of *Gossypium intermedium* being found anywhere in Eastern Bengal, but local officers may not have suspected its existence as a garden crop grown in villages near houses and not in the fields. The real source of the Dacca muslin cotton is a matter sufficiently important for close investigation.

The cultivation of *burhi* cotton in Chota Nagpur is probably capable of extension. Hand gins have been supplied by the Deputy Director of Agriculture, Bengal,

for the use of villagers. The cultivation of the cotton crop generally in Chota Nagpur is on the decline, owing to the restriction of the *daha* system of cultivation. This system consists in burning thick layers of jungle on the land selected for the cotton crop. The land is thus fertilised with the ashes, and weeds are killed. If there is not enough jungle on the selected site, jungle including often valuable trees, is cut down at some distance and carried there. The system is a wasteful one, and its restriction cannot, therefore, be deprecated. Tree cottons are grown in the district to a limited extent. The plants give a fair return for three or four years after which their yields diminish.

During the same month a visit was paid to the Central Provinces and Berar Exhibition, and full advantage taken of such a favourable opportunity of studying samples of cottons from all parts of the province. Side by side with the experiments which are being conducted for the improvement of the local *jari* and *varadi* by the selecting out of a superior race known as *malvensis*, work of great importance has been done in the introduction of *burhi* cotton. The staple has been favourably reported on, but something further is required in the way of strength, and it is hoped the provincial department will attain this quality by selection. In the course of a conversation with an enterprising gentleman who cultivates about 1,000 acres of land near Yeotmal, it was learnt that *burhi* cotton is thoroughly at home in low lying ground where *jari* was killed by excessive rain in the last season. There is thus a chance for the introduction of *burhi* into areas of heavier rainfall, and Mr. Clouston has arranged to work out this point. It should not be grown, however, on the higher and drier lands which are exactly suitable for *jari*. Mr. Hemingway, Director of Agriculture, stated that a good deal of cotton wilt had been reported from the Satpuras, but he himself thinks that it is not really wilt, but damage caused by the heavy rainfall. He also stated that *bani* requires a heavier rainfall than *jari*, that the

cultivation of the former has declined owing to a long succession of abnormally dry seasons, and that with more favourable climatic conditions, *bani* will probably again come into favour. He also says that the *ryots* are quite alive to the necessity of selecting good seed and hand gin what is required for their own use.

In the adjoining tracts of the Nizam's territory, a particularly fine cotton known as *karkeli* is grown from its centre of trade. A quantity of the best *karkeli* seed cotton was obtained, and after ginning, was submitted to Messrs. Tata for opinion. They valued it as equal to fine Broach and further stated that the chief characteristic of the *karkeli* variety of cotton is its tension which is greater than that of any other variety of Indian cotton, and that it is greatly valued by the mills on that account. The Cotton Specialist has supplied seed to all parts where the coarser cottons are grown, and when samples of the produce are received, he will, if the results are promising, be able to arrange for its introduction on a larger scale. This cotton consists of *jari* of a very superior type with an admixture of *bani* and *upland Georgian*. It is even in staple and general characteristics. However the fact that inferior cotton is brought down from Central India for mixing purposes, is to be deplored.

At Barsi also a good type of cotton, mostly *bani*, used to be brought in from the Nizam's territory, but now, owing to the substitution of inferior varieties, its reputation has sadly diminished. It may be mentioned here that there is little direct proof of deterioration of the cotton plant anywhere in India, and that falling off in quality is greatly due to substitution of inferior varieties, or to mixture of good and bad varieties at the ginning factories. During January, 1909, the Cotton Specialist toured in Gujarat to study the factors of environment which influence the characteristics of the distinct varieties of cotton which exist there. Such a study may make it possible to formulate general laws for the production of different varieties of cotton.

Many of the Kathiawar States this year have gladly undertaken to carry out experiments with superior cotton, and there is hope that the former good varieties will again find a footing there.

The experiments with *Bourbon* cotton at Nadiad farm are very promising. Years ago partial success was obtained in its cultivation in the Kaira district, and the ultimate failure was perhaps due to the ignorance of the requirements of a perennial cotton which needs careful pruning among other details. Some of the samples of cotton were valued very highly. Mr. Spence might have obtained success further north at Deesa if he had tackled the problem in the right way. Some samples of Bourbon cotton from the Coimbatore district have been favourably reported on by a Bombay merchant.

Bourbon is probably the only foreign tree cotton worth experimenting with in India, and an attempt is at present being made to obtain sufficient information to enable definite schemes to be formulated for its cultivation on a larger scale. Its chief virtue at present seems to be that it is not suitable for ordinary cotton soil tracts where it would immediately suffer by admixture, but it would thrive on red and sandy soils where cotton is not a usual crop. In the Madras Presidency it is almost the sole memorial of the long defunct cotton department, and it has there suffered from long and unmerited neglect.

In February, 1909, the Cotton Specialist attended the Board of Agriculture meeting at Nagpur, and there discussed cotton matters with the officers interested. In March he toured through the southern Mahratta country, Madras Presidency and Bangalore where he advised the recently appointed Economic Botanist as to the experiments he should undertake.

In the previous year three Bombay cottons were reported as having given satisfactory results at Bellary. Broach, however, shows a steady decline. The peculiar yellow coloured cotton of the Madras Presidency is objected to

in the Bombay market where a white colour is one of the chief desiderata. A constant introduction of fresh seed would only partially remove the difficulty, as even in the case of cotton at Dharwar from imported seed, it was pointed out to Mr. Gammie that it was darker in colour. In the southern part of the Madras Presidency it has been proved that the *karangani* is superior to *uppam*, and steps are being taken to distribute quantities of the former. The introduction of the seed drill is considered the most important part of the work done.

From Burma intimation was received that the department had resolved to begin experiments; so, as a preliminary, sets of seeds of standard varieties were supplied in order that their behaviour might assist in arriving at some idea on what lines the trials should ultimately run.

3. *Collection of Varieties.*—A large collection of annual and perennial cottons, both indigenous and American, has been kept under observation at Kirkee and Ganeshkhind. The only tree cottons which gave any promise of success, were Bourbon and Spence cotton which is ordinarily indistinguishable from Bourbon.

4. *Distribution of Seed.*—Considerable quantities of cotton seed have been supplied, in all, to 47 persons in various parts of India.

5. *Identification and Valuation.*—A good many samples have been sent in for identification and valuation. All samples received for valuation were submitted to Bombay merchants, and the verdicts transmitted to the senders. An assistant recently appointed with a previous knowledge of cotton valuation, has studied the subject in Bombay and ought to prove of great help in the future in this line.

It is hoped to keep in close touch with cotton merchants. The Cotton Specialist has met and talked with a good many, and he feels that the trader and not the farmer is the chief obstacle in the way of improvement.

6. *Programme for 1909-10.*—It is proposed to tour in Eastern Bengal and Chittagong Hill Tracts in the autumn to advise on the possibilities of improvement of cultivation and introduction of suitable superior varieties. A visit may be paid to Burma later on. A scheme will be formulated for extended trials of Bourbon cotton, at least in the Madras and Bombay Presidencies. A tour will again be made in Gujarat to continue the investigation into the conditions which affect the production of cotton. This enquiry is also carried on wherever touring is done. The introduction of superior cotton into Kathiawar and of *karkeli* cotton into *jari* districts, will depend on the results achieved. Finally the Cotton Specialist is at the disposal of any one who may require his advice or assistance.

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