PROSPECTUS

OF

THE AGRICULTURAL RESEARCH INSTITUTE AND COLLEGE, PUSA

(Sanctioned by the Government of India, Revenue and Agricultural Department)

CALCUTTA
SUPERINTENDENT GOVERNMENT PRINTING, INDIA
1906

PROSPECTUS

OF

THE AGRICULTURAL RESEARCH INSTITUTE AND COLLEGE, PUSA

(The Prospectus is subject to such alterations as may from time to time be ordered.)

1. PREFATORY.

THE Agricultural Research Institute and College, Pusa, owes its inception to the generosity of Mr. Henry Phipps who in 1903 placed at the disposal of Lord Curzon, then Viceroy and Governor General of India, a donation of £20,000 (which he afterwards raised to £30 000) with the request that it might be devoted to some object of public utility in India, preferably in the direction of scientific research. Part of this donation was devoted to the construction of a Pasteur institute at Coonoor in southern India, and it was decided that the balance should be utilized in erecting a laboratory of agricultural research which, it was hoped, would form a centre of economic science in connection with that occupation on which the people of India mainly depend. This conception was subsequently enlarged, and the Government of India have now constructed a college and research institute to which a farm of some 1,300 acres is attached for purposes of experimental cultivation and demonstration.

In 1903, when the research station was sanctioned, it was intended to combine it with a college which should give a general agricultural education and should serve as a model for the few agricultural colleges and schools of very unequal merit which then existed in India. Recently, however, this conception of the functions of the Pusa College has undergone a material change. It is now recognised that the first and most essential condition of any permanent improvement in the agricultural methods of this country is the widest possible diffusion of an organised knowledge of scientific and practical agriculture, and at the same time it is desired to make the country as far as possible self-supporting in the

matter of development of agricultural training and research. A comprehensive scheme for the promotion of agricultural education throughout India, has accordingly been drawn up, as the result of which it is hoped that every important province will soon be provided with a fully equipped college where students will for three years receive practical and scientific education in agriculture. The position which the Pusa College is intended to occupy in relation to this general scheme is that of a higher teaching institution. Its main object is to enable students who have passed with distinction through a course of a provincial college, by means of a post-graduate course in one of the specialised branches of agricultural science, to qualify for the higher branches of agricultural work.

2. THE PUSA ESTATE.

The estate consists of 1,300 acres, of which 400 are arable, 400 are pasture ; nearly all the field crops of the plains can be grown there. The farm buildings are up-to-date, and herds of breeding and milch cattle are maintained. There are complete arrangements for the manufacture of indigo and the curing of tobacco. Poultry breeding is being carried on ; there is a large and well-laid-out orchard and botanical garden. Every facility for the practical teaching of agriculture and agricultural subjects has been provided. The students' laboratories are extensive, well lighted and equipped ; there is a library for the use of students. The students' hostel is complete, and there is ample accommodation for 70 students. Waini, on the Bengal and North-Western Railway, is the nearest railway station. It is six miles from the college by a good road. There is a telegraph and post office within the estate.

3. CONSTITUTION AND STUDIES.

1. *CONTROL.*—The College is under the general supervision of the Inspector-General of Agriculture in India and is under the direct control of the Director of the Research Institute and Principal of the College.

2. *STAFF.*—The superior staff of the College consists of —

1. The Principal.
2. The Imperial Agricultural Chemist.
3. The Imperial Mycologist.
4. The Imperial Entomologist.
5. The Imperial Economic Botanist.
6. The Imperial Agriculturist *

* The post of Imperial Agriculturist has been temporarily abolished in the post of Director and Principal.

7. The Imperial Agricultural Bacteriologist.
8. The Second Imperial Entomologist.

3. *COURSE.*—The ordinary College course extends over two years, and the students will be trained in one or other of the following sections of agricultural science, no students being trained in more than one section at a time :—

1. Agricultural Chemistry.
2. Economic Botany.
3. Economic Entomology.*
4. Mycology.
5. Agricultural Bacteriology.†
6. Agriculture.

4. *SYLLABUS.*—In the absence of experience of the class of student likely to be received, it is impossible to lay down a permanent syllabus of the training in each subject. The syllabus that follows is tentative and is subject to the condition that time will not be wasted in taking students over ground that is already familiar to them.

I.—Agricultural Chemistry.

(TWO YEARS' COURSE.)

(*i*) A course of lectures and laboratory practice of the same type as laid down in the *Standard Curriculum for Provincial Colleges.*

(*ii*) A course or courses of lectures in advanced chemistry which shall follow such lines as have an important bearing on agricultural science. Each student will then take up a particular line of investigation suggested to him by the lecturer. At the end of the course each student will write an essay embodying the whole of his work, and the results positive or negative he can deduce therefrom.

II.—Botany.

(TWO YEARS' COURSE.)

(*First year.*)

(*i*) *Physiology of Plants.*—The course will be mainly practical and will be based on Darwin and Acton's *Physiology of Plants* (Cambridge University Press).

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* The entomological course will be for one year only.

† As the appointment of Imperial Agricultural Bacteriologist is now vacant, instruction cannot be provided at present in Agricultural Bacteriology.

The work will illustrate the effect of various conditions on plant development and will include —

(*a*) Respiration.
(*b*) Assimilation.
(*c*) Nutrition.
(*d*) Transpiration.
(*e*) Growth.
(*f*) Movements.

(*ii*) *The Improvement of Plants.*—The lectures will deal firstly with the principles underlying the modern development of plant-breeding, such as Mendel's Law and Mutation, and secondly with the particular methods adapted to Indian conditions, and this part of the course will be supplemented by field work.

The subjects treated will be—

(*a*) Evolution, Variation and Mutation.
(*b*) Selection.
(*c*) Hybridization.

(*iii*) *The Principles of Indian Fruit Growing.*—The course will include—

(*a*) The general management of a modern fruit garden.
(*b*) Special processes, such as Propagation, Pruning and root-pruning, Weathering.
(*c*) Disposal of the produce.

In the case of students who show special aptitude for work in Economic Botany and who are likely to become qualified to undertake original work, the course will be extended to two years.

(*Second year.*)

In general this second year's work will deal with the practical application of the principles of plant improvement, and a general knowledge will be given to students of the planting, cultivation and improvement of plants which are of special economic importance in their respective provinces.

III.—Entomology.

(ONE YEAR'S COURSE.)

(*i*) Collecting, pinning, setting.
(*ii*) Classification. How to use text-books.
,, How to use the collection.
(*iii*) Anatomy of cockroach or other form.
Comparative anatomy as shown by dissection, mouth parts, etc.
Terms used in classifying.
(*iv*) Classification and terms used in each order.
(*v*) Actual identification and revision of the collection.
(*vi*) Biology and life histories—general, special and details
(*vii*) An account of each family in order.
(*viii*) Pests :—first general, then special by order, then special by crops.
(*ix*) Complete list of the injurious insects in India.
(*x*) Preparation of leaflets and lecture course for the province, with exhibition collection of insects of that province.
(*xi*) Useful insects (lac, silk, apiculture).
(*xii*) Beneficial insects and birds.
(*xiii*) Preventive and remedial measures.

IV.—Mycology.

(TWO YEARS' COURSE.)

1. *A Revisionary Course in Plant Anatomy and Physiology.*—Time—two to three months.

Anatomy. Histology of the cell and tissues. Anatomy of the root, stem, and leaf.
Physiology of nutrition.

2. *General Mycology.*—Time—six months.

Definition and characters of the fungi.
Structure of the Thallus —

(*a*) Vegetative portion, mycelium, rhizomorpha, sclerotia.
(*b*) Reproductive portion ; sporophores : spores ; germination.

Life habits of fungi.
Dissemination.
Polymorphism.
Food of fungi, saprophytes, parasites.

Symbiosis.
Heteroecism.
Specialisation of parasitism.
Classification. The study of the six main groups of fungi with examination of types.

3. *Pathological Mycology.*—Time—15 months.
Causation of disease by fungi. Infection.
Effects of parasitic fungi on plants.
Diagnosis of disease : symptoms of fungus attack.
Prevention and treatment of fungus diseases of plants.
Predisposition of plants to disease : immunity.
Factors of disease. Epidemics.

A general study in field and laboratory of the principal fungus diseases of crops in India.

A more detailed study with experiments of a selected fungus disease.

If possible, the student should accompany a trained assistant in a field enquiry for the purpose of giving him practice in independent observation and collecting information.

V.—Bacteriology.*

A short course in bacteriological methods, preparation and sterilization of media and the cultivation of bacteria.

Students who have passed through this training satisfactorily will take part in the research work of the laboratory under supervision.

VI.—Agriculture.

Special instruction will be given in the management of field and garden crops and orchards, and in the use of agricultural machinery, tools and implements and in cattle, sheep and poultry breeding.

As a temporary measure to assist the provinces which are not in a position to train their own men as superintendents of farms or for other positions requiring a practical agricultural education, a course in general agriculture will be given.

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5. *TERMS.*—The terms for students are as follows :—
Autumn Term—From 1st June to 15th November.
Vacation—From 16th November to 5th January.
Spring Term—From 6th January to 31st March.
Vacation—From 1st April to 31st May.

* As the appointment of Imperial Agricultural Bacteriologist is now vacant, instruction cannot be provided at present in Agricultural Bacteriology.

6. *CERTIFICATES.*—For the present it has been decided not to hold periodical and final examinations, but certificates signed by the head of the section and countersigned by the Principal, will be presented to students who have passed through the College course with credit.

4. ADMISSION RULES.

1. *Accommodation.*—The total number of students that can ordinarily be admitted in each of the following sections every year is as follows :—

Agriculture	8
Agricultural Chemistry	8
Mycology	8
Entomology	8
Botany	8
Agricultural Bacteriology*	4
	44

The number of studentships to be allotted each year to the respective provinces as well as the number of nominations, if any, to be made by the Principal, will be decided by the Principal before the 1st April, after consultation with the provincial authorities as to their requirements, and communicated to the Local Governments and Administrations concerned.

2. *Students.*—There will be three classes of students—

(*i*) Students nominated by a local Government or an administration.

(*ii*) Students deputed by a Native State, on the nomination of the Inspector-General of Agriculture in India.

(*iii*) Private students.

3. Students nominated by a Local Government or Administration should ordinarily be men who have passed with credit through a provincial agricultural college, or are graduates of an Indian University or possess a degree or diploma of approximately the same standard granted by any other educational institution.

4. Students deputed by a Native State may be admitted on the application of the State concerned, provided that accommodation is available. Applications should be addressed, in the first instance, to the Inspector-General of Agriculture in India, Nagpur, Central Provinces, and should reach him before the 15th March. The nomination of such students is made by the Inspector-General of Agriculture in India, and

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his nomination should reach the Principal before the 1st April, as provided in Rule 1 above.

5. Students of class (*ii*) above will be required to pass a satisfactory test to be applied by the chief of the section concerned at Pusa.

6. (*i*) *Private Students.*—Private students may be admitted by the Principal provided that accommodation is available. Candidates for admission should be not less than 19 years of age, and should submit their applications to the Principal before the 1st April in each year. Ordinarily only candidates will be admitted who have the same qualifications as are prescribed for students nominated by a Local Government or Administration in Rule 3 above, and such candidates may also be required to pass the test mentioned in Rule 5 above.

(*ii*) A private student must attach to his application (*a*) a certificate of age, (*b*) a health certificate signed by a Civil Surgeon testifying to the candidate's physical fitness for such out-door work as is required to be done in the Agricultural Department, (*c*) a certificate of good moral character from the Principal of the Agricultural College from which he graduated or from any one else of influential position. The certificates (*b*) and (*c*) must bear a date within six months of the date of application for admission into the College.

(*iii*) The Principal may relax any of the conditions imposed under rule (*ii*), should he consider it desirable.

(*iv*) The names of those private students who succeed in obtaining the College certificates will be entered by the Principal in a register to be kept for the purpose, and will be communicated to the Directors of Agriculture in the various provinces so that these private students may be offered employment if their services are required. The names will also be published in the *Gazette of India* and in provincial Government gazettes.

7. It will be at the discretion of the Principal with the advice of the scientific officer in charge of the section, to declare at any time the unfitness of a student for training and to require his removal from the College.

8. The expenses of a student at the College, will, it is estimated, not exceed Rs. 25 per mensem. But the following sums will approximately be required for the purchase of books :—

	Rs.
Agricultural Chemistry	15
Economic Botany	15
Entomology	22
Mycology	25
Agricultural Bacteriology	15
Agriculture	15

10. Local Governments will be left to make students whom they depute to the College such allowances and grants as they think fit. In the case of students already in Government service the allowance should not exceed the pay of their grade, and in the case of other students they should not exceed Rs. 50 a month.

11. Caution money and initial deposits will not be required from students nominated by Local Governments, except in the case of students required to undergo training at the College at their own expense, who must deposit with the Principal a sum of Rs. 50 to meet the initial cost of books and in addition Rs. 50 as caution money.

5. DISCIPLINARY RULES.

1. The Director and Principal is charged with the general control of the students, the housing and domestic arrangements, and the maintenance of discipline, and he will from time to time issue such rules and regulations as may be necessary to secure these objects. All the correspondence relating to the training of students should be addressed to the Director and Principal, Agricultural Research Institute and College, Pusa, Bengal.

2. (*i*) *Quarters.*—The Principal will allot to students on arrival such quarters as may be available. The College quarters are tenable during the whole period of the student's course. For the present no rent will be charged for the quarters, but the Government of India reserve the right of withdrawing the concessions from all or any class of students entering the College hereafter.

(*ii*) Students must make their own arrangements for meals. Separate dining rooms will be provided for different castes and religions, and meals will not be allowed in quarters without the consent of the Principal.

(*iii*) Every student will be responsible for articles placed in his charge. In case of loss or damage arising from carelessness he may be called upon to pay.

(*iv*) Students will not be allowed to keep dogs. Horses and cattle cannot be kept without the permission of the Principal.

(*v*) No student may leave the estate premises without the permission of the Director and Principal. No student may be absent from his quarters after 10 P.M. without the permission of the Director and Principal.

3. *Library.*—The use of the library will be allowed subject to the library rules.

4. *Books and Instruments.*—The list of books required by students of each section will be published by the Principal from time to time. Apparatus and other laboratory requirements will be provided free, but students using them will be responsible for their safe custody and return.

5. *Leave.*—During the course of instruction no student may leave Pusa without the order of the Principal. Subsidiary rules regarding leave will be made by the Principal from time to time.

6. *Holidays.*—Such of the usual gazetted holidays as are allowed will be notified from time to time.

7. *Punishments.*—Students are liable to the following punishments which may be imposed by the Principal :—

Entry in conduct register.

Stoppage of leave or fine.

Removal or dismissal from the College. An extract of the order of this kind passed by the Principal shall be forwarded to the Local Government or Native State concerned for information.

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REPORT

OF THE

Agricultural Research Institute and College, Pusa

(Including Report of the Imperial Cotton Specialist)

1907-09

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1907-09

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 gauge. 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 stemborers 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 *karkli* 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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REPORT

OF THE

Agricultural Research Institute and College, Pusa.

(Including Report of the Imperial Cotton Specialist)

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Report of the Agricultural Research Institute and College, Pusa.

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1909-10.

INTRODUCTORY.

IN presenting the report of the past year of the Agricultural Research Institute and College at Pusa, and that of the Imperial Cotton Specialist, I shall confine myself to a brief mention of the more important work undertaken in each section.

Agriculture.—The *Permanent Manurial and Rotation* experiments and the *Permanent Pasture* experiments have been continued according to the scheme described in the Proceedings of the Board of Agriculture, 1908. Sufficient time has not elapsed for making deductions from their results. Perhaps amongst the most useful work carried out is that of the preservation of fodder. In a country like India where cattle-food supplies are subject to the vicissitudes of an uncertain climate, this subject is of the highest interest. The production of ensilage on the American principle has been found the most satisfactory method of preservation. Maize was found to give the most nutritious food when thus prepared, but in point of yield per acre sorghum has given more weight and is therefore more economical. An objection to the American system of making ensilage in this country is the expense of constructing the silo. Experiments, however, are in progress

with a view of devising a cheap indigenous pattern which, if successful, will not only enable the better class of cultivator to adopt siloing, but will be of use perhaps to Government Departments in the preservation of fodder against famine years. As regards future work, that coming under the head of "Extension of Botanical Work" will doubtless prove the most important. The growth of selected varieties of wheats in extension of the work now being done by the Imperial Economic Botanist will be carried out on a practical scale with a view to still further extension in the future.

Botany.—No part of a scheme for the improvement of agriculture gives greater promise of success than that which deals with improvements emanating from the treatment of the plant. This is especially the case in India where not only are the plants of most crops degenerated specimens, but where the poverty of the cultivator makes improvement entailing the use of capital well-nigh impossible. By the introduction of a better plant, it is easily possible to increase yield and improve quality without adding to the cost of cultivation. The work which Mr. A. Howard, the Imperial Economic Botanist, is carrying out on *wheat* requires special recognition. The wheats which were sent home last year for testing have been found to rank in the same class as American and Canadian Spring wheats which command the highest price in the English market. It is almost needless to point out that these facts should have a most profound effect upon the export wheat trade of India. I desire here to record the appreciation felt for the invaluable assistance given by Mrs. Howard, who equally with her husband has accounted for the work of this Section.

Chemistry.—The principal work undertaken by this department during the past year has been the study of *Soil Gases* in relation to other constituents in the soil, the examination into the nature of *Usar* land and the investigations into the *Water Requirements of Crops.* The work of the first two is not in a sufficiently advanced stage to

need reference at this moment, but attention may be invited to Dr. Leather's work on the *Water Requirements of Crops*. In India where water is the prime factor underlying the successful growth of crops, its conservation and its economic use are of first rate importance. These remarks apply equally whether the water is derived from the monsoon rainfall or the irrigation canal. How much water is transpired by various crops, and during what period of growth does the crop require the principal portion of this water, are questions of as great importance to the agriculturist as to the irrigation engineer. In Chapter XI of the Report of the Indian Irrigation Commission, 1901-1903, the Commissioners remarked, "In the course of our investigations, we have been struck with the small amount of attention which appears to have been given by the Departments of Agriculture and Public Works to matters connected with the application of water to cultivated crops. At present, most of the information which can be had on these points has to be taken from papers published by the Agricultural Bureau in America. . . . . We consider it extremely desirable that expert enquiry should be directed to these important matters, which are so intimately connected with the development of irrigation."

This enquiry Dr. Leather has undertaken and in Memoir No. 8, Chemical Series, he has published the results of his work on the first section of the investigation, namely, that which deals with the total amount of water transpired by the crop and the period of growth during which the greater part is assimilated. The ratio between the amount of water transpired and the ultimate weight of dry crop is worked out for most of the principal Indian crops.

Entomology.—One of the principal features of the work of this section is the attention which is being paid to industries that depend upon the products of insects. Thus Eri, Mulberry and Tussar silk and the cultivation of Lac are taking up much of the time of Mr. Maxwell-Lefroy, the Imperial Entomologist, and his staff. The Eri silk industry

has spread considerably in Tirhoot, Bhagalpur and Patna, where owing to their proximity, these places are under the direct influence of this Institute. It is also to be found in Malabar, Dharwar, the West Coast, Gujarat, Kathiawar, Sind, Patiala, Rohilkhund, Betul, Chanda and Murshidabad. Progress is at present somewhat retarded by the want of middlemen for collecting the cocoons from the rearers and conveying them to the mills, but it is expected that enterprise will eventually overcome this difficulty.

Mycology.—The investigation into the *Blister Blight of Tea* carried out by Mr. W. McRae while he officiated as Imperial Mycologist, has been the most important new work undertaken during the year. The disease which has been known for years in North-East Assam appeared for the first time in Darjeeling in 1908. In 1909, it extended, and this led to the Darjeeling Planters' Association asking the assistance of this Institute. It has spread still further this year into the Dooars and the Terai and its progress will be watched with anxiety by all interested in tea.

The *Palm Disease* in the Godavery Delta has not ceased to engage the attention of this Department, and recommendations have been made for continuing the work of repression, especially in the Kistna District where, in spite of the repeated warnings of the Imperial Mycologist, it was being neglected. A full account of the disease and measures taken to check it is in the press and will appear shortly.

Bacteriology.—It is only necessary to mention that with the appointment of Mr. C. M. Hutchinson as Imperial Agricultural Bacteriologist, this section has been opened during the year. The importance of the study of the biological aspect of soils in this country cannot be overestimated, and much useful information is anticipated from investigations in this quarter.

Cotton.—The importance of the cotton plant not only to India but to the British Empire has led the Government

to appoint a whole-time officer for this particular crop. Mention may here be made of the more important recommendations of the Imperial Cotton Specialist which will be found embodied in his report in greater detail. In *Eastern Bengal and Assam*, the prevalent type is that known as *Gossypium neglectum* var. *Assamica* of Watt and is commonly called the Garo Hill Cotton. It is not used in commerce as cotton but as a substitute or adulterant in wool manufacture and any attempt to improve it from the point of view of the cotton merchant would result in a serious diminution of price. The Imperial Cotton Specialist recommends that in any experiments carried out by the Department, this type of cotton should be adhered to, lest the experience of generations which has taught the use of a kind of cotton capable of growing under excessive rainfall and the primitive agriculture of the Hill tracts, be lost and the present variety substituted by an unsuitable one. He, therefore, advises that trials should be confined to improving in this one type, the length of staple and the percentage of cotton to seed but that no attempt should be made to alter the special characteristics of the product.

In *Bengal* the cottons appear altogether to be of an inferior type. Trials should be confined in this Province to the possibilities of *G. intermedium* and *G. hirsutum*, the latter preferably in its two forms of *Buri* and Cambodia.

In the *Central Provinces*, it is pleasant to find that Mr. Clouston, Deputy Director of Agriculture, has selected a plant of the *Buri* variety which is promising well and that most valuable work is being done in these provinces by the introduction of *Buri*. The recommendations of the Imperial Cotton Specialist in regard to these provinces may be summarised as under :—

(1) The introduction of *Buri* to accompany *Bani* but not to oust *Jari*.

(2) The improvement of *Bani* in its percentage of cotton.

(3) The isolation of the different types of *Jari*.

The report of the Imperial Cotton Specialist so far as other Provinces are concerned does not call for any comment.

Publications.—In addition to the Agricultural Journal of India, the Memoirs of the Department of Agriculture in India, Bulletins and Leaflets, two publications of importance have issued from the Institute during the past year, namely, *Indian Insect Life* by Mr. Maxwell-Lefroy assisted by Mr. F. M. Howlett and *Wheat in India* by Mr. and Mrs. Howard. *Indian Insect Life* containing 786 pages of printed matter and 619 illustrations has been well received both in India and abroad and is without doubt the most advanced and comprehensive manual of Indian insects yet published. *Wheat in India* containing 288 pages and 18 illustrations, deals in a complete manner with the production, varieties and improvement of Indian wheat. In order to be useful to all interested in the various aspects of wheat production, the scope of the book has been made as wide as possible.

Students.—Out of the students admitted in the previous year, nine continued their course and of these seven left during the year after the completion of their training and one was recalled to his province before the expiry of his term. Four new students were admitted during the year, *viz.*, one each in Chemistry, Mycology, Entomology and Agriculture. In the short practical courses in Agriculture, Fruit-growing, Silk-culture, Lac cultivation, Cattle Breeding and Management and the like, 39 students were admitted, some of whom took up more than one subject.

BERNARD COVENTRY,
Offg. Inspector General
of Agriculture in India.

SIMLA;
The 1st October 1910.

REPORT OF THE DIRECTOR, AGRICULTURAL RESEARCH INSTITUTE AND COLLEGE, PUSA, FOR THE YEAR 1909-1910.

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

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1. *Charge of Office.*—Mr. B. Coventry held charge of the office of Director up to the 9th May 1910, with the exception of one month in September-October 1909, when he was on privilege leave and Mr. H. Maxwell-Lefroy, M.A., F.E.S., F.Z.S., Imperial Entomologist, acted for him during his absence in addition to his own duties. In consequence of his appointment as Officiating Inspector General of Agriculture in India, Mr. Coventry relinquished charge of the office of Director on the 9th May 1910, and I was appointed to officiate for him in addition to my own duties.

2. *Staff.*—Dr. J. Walter Leather, Ph.D., F.I.C., F.C.S., Imperial Agricultural Chemist, returned from leave on the 27th October 1909 and took over charge of the chemical section from Mr. H. E. Annett. The latter has been deputed to act as Agricultural Chemist, United Provinces, from the 3rd November 1909. The charge of the mycological section was taken over by me from Mr. W. McRae, M.A., B.Sc., on the 27th December 1909, when I returned from leave, and immediately after Mr. McRae proceeded to Madras to join his new appointment as Mycologist to the Government of Madras. His successor, Mr. F. J. F. Shaw, B. Sc., A.R.C.S., joined his appointment as Supernumerary Mycologist on the 28th January 1910. Mr. C. W. Mason, Supernumerary Entomologist, left the Department on the 19th December 1909, and Mr. T. Bainbrigge-Fletcher, R.N., F.E.S., joined this Institute as Supernumerary Entomologist on the 8th April 1910. The Second Imperial Entomologist, Mr. F. M. Howlett, B.A., F.E.S., has been on leave since the 9th September 1909 and

is expected to return in January next. Mr. C. M. Hutchinson, B.A., joined the Department on the 24th December 1909, as Imperial Agricultural Bacteriologist. The charge of the Farm was relinquished by Mr. E. Shearer, Imperial Agriculturist, on the 17th July 1909, in consequence of his promotion to the post of Assistant Inspector General of Agriculture in India and the Director was placed in charge of the duties of the Imperial Agriculturist in addition to his own duties. Mr. G. C. Sherrard, B.A., Supernumerary Agriculturist, was appointed to be Assistant Agriculturist with effect from 17th July 1909. He was on privilege leave from 2nd to 20th November 1909, and from 6th June 1910 to 6th July 1910. Mr. A. McKerral, M.A., B.Sc., who has been appointed Assistant Inspector General of Agriculture in India, *vice* Mr. E. Shearer, resigned, has been lent to the Pusa staff to undertake the work of Imperial Agriculturist under the Director as a provisional measure. He joined his duties at this Institute on the 19th June 1910. The botanical section was in charge of Mr. A. Howard, M.A., A.R.C.S., F.L.S., up to 30th April 1910, when he proceeded on leave to England. Mr. G. P. Hector, M.A., B.Sc., Supernumerary Botanist, was transferred to Eastern Bengal and Assam on the 14th July 1909, and the services of Mr. E. Holmes-Smith, B.Sc., Economic Botanist designate of Burma, were transferred to this Department with effect from the 15th July 1909, for appointment as Supernumerary Botanist. The latter has been on deputation in the Bombay Presidency since the 6th March 1910, to acquire experience of work in a province.

The European Scientific Staff of the Institute consisted of the following : —

(1) The Imperial Agricultural Chemist with one Supernumerary, (2) the Imperial Mycologist with one Supernumerary, (3) the Imperial Entomologist with one Supernumerary, (4) the Imperial Economic Botanist with one Supernumerary, (5) the Second Imperial Entomologist, (6)

the Imperial Agricultural Bacteriologist, (7) the Assistant Inspector General of Agriculture in India (temporarily in charge of the agricultural section) with the Assistant Agriculturist.

During the year under report, the pay and position of several of the senior Indian assistants of the institute were improved and the first assistants in each section as well as other assistants engaged in teaching and research work have been admitted to gazetted rank.

3. *Scientific Work.* The scientific work of the Institute during the year is indicated in the reports of the various Sections.

4. *Buildings, Grounds, etc.* In consequence of the transfer of the head quarters of the Inspector General of Agriculture in India to Pusa, two blocks of new quarters have been departmentally constructed for the use of his staff and in addition some old buildings have been placed at his disposal. The grounds surrounding the College building have been fully laid out and arrangements made for irrigating the lawns.

5. *Students.* Out of the students admitted in the previous year, 9 continued their course and of these 7 left during the year after the completion of their training and one was recalled to his province before the expiry of his term. Four new students were admitted during the year, *viz.*, one in Chemistry (an Assistant of the Agricultural Chemist, United Provinces) for a three months' course, one in Mycology (a private student from Bombay), one in Entomology, from the Central Provinces Department of Agriculture, and one for a general course in Agriculture from the Punjab Department of Agriculture. The private student in Mycology has, however, abandoned the course and left the Institute. There were at the end of the year four students under training, *viz.*, one in Chemistry, two in Entomology and one for a general course.

The short courses in practical agriculture and in other allied practical subjects inaugurated last year at Pusa

were continued. The number of students admitted to the various sections for these courses was as follows:—Six in fruit-growing, eighteen in silk-culture, ten in lac cultivation, nine in cattle breeding and management, three in poultry management and three in tillage implements and agricultural machinery. The students for these courses came from different parts of India and some of them took up more than one subject.

6. *Publications.*—This work has been continued. During the year under report two new books, one "Indian Insect Life" by Mr. H. Maxwell-Lefroy, Imperial Entomologist, assisted by Mr. F. M. Howlett, Second Imperial Entomologist, and the other "Wheat in India" by Mr. A. Howard, Imperial Economic Botanist, and Mrs. Howard, were published in addition to the Agricultural Journal of India, the Memoirs of the Department of Agriculture in India, Bulletins and Leaflets.

7. *Library.*—The revised catalogue of the library is still in the press. Over a thousand volumes have been added to the library during the year.

8. *General Health of the Station.*—The general health of the station during the year under report was good, excepting in the monsoon period. Relief was afforded in the hospital to 6,231 new cases, of which 6,015 were treated in the outdoor department and 216 admitted as indoor patients. These figures show an increase of 2,918 and 112 respectively over last year's totals. The increase in attendance was due to the greater prevalence of malarial and allied fevers during the months of July, August and September, 1909. 99 cases amongst European officers and their families were attended to.

The daily average number of patients treated was 6·96 indoor and 48·97 out door as against 4·68 and 25·05 respectively during the previous 12 months.

Five deaths occurred in hospital—two cases from pneumonia in aged and debilitated subjects, one from malarial cachexia and two from *Kala-Azar*.

Eighty-eight surgical operations were performed, of which 4 were major and the remainder minor.

The prevailing diseases were malarial fevers, bowel complaints and rheumatic and skin affections. Malarial fever cases were diagnosed microscopically before treatment.

There were no cases of infectious diseases, except a case of chicken-pox (imported). Eight primary and three revaccinations were performed in the early part of the year.

9. *Accounts.*—The total expenditure incurred during the year was Rs. 3,12,427 as against Rs. 3,23,900 of the preceding year. The principal items of expenditure are pay of gazetted officers and establishment Rs. 1,78,680, travelling allowance of officers and establishment Rs. 14,699, publications Rs. 30,000 and farm expenditure, scientific apparatus, books, contingencies, etc., Rs. 89,048.

The gross receipts during the year by sale of farm produce, milk and other miscellaneous articles amounted to Rs. 5,573 as against Rs. 9,680 of the preceding year. The decrease is due to the abnormal rainfall (amounting to 72 inches) which damaged the crops.

REPORT OF THE IMPERIAL AGRICULTURIST FOR THE YEAR 1909-10.

(A. McKerral, M.A., B.Sc.)

1. *Charge and Establishment.*—Mr. Ernest Shearer, Imperial Agriculturist, relinquished charge of the farm on 16th July 1909 on his promotion to the post of Assistant Inspector General of Agriculture in India, and his duties were taken up by Mr. Bernard Coventry, the Director, Agricultural Research Institute, in addition to his own work. Mr. G. Sherrard, who had previously acted as Supernumerary Agriculturist, was appointed Assistant Agriculturist. Amongst the subordinate staff, Mr. G. N. Desai, First Farm Overseer, was transferred in March 1910, to the Agricultural Department of the Bombay Presidency, and Mr. Ikramuddin, the Second Farm Overseer, was promoted to First Farm Overseer in his place. Mr. Ziauddin Hyder, fieldman, was in charge of the Poultry until promoted in April 1910 to the post of Second Farm Overseer, Mr. Nizamuddin Hyder being appointed in his place. Mr. Judah Hyam, the Veterinary Overseer, remained in charge of the breeding herds as before. During the year, the Government of India were pleased to raise him to Gazetted rank along with certain other Indian Assistants of the Institute.

2. *Training.*—The two students Bhai Sunder Singh and Bhai Kharak Singh, sent by the Punjab Agricultural Department for a general course of agriculture, completed their training and returned to their province to take up respectively the posts of Assistant Director of Agriculture and Assistant Professor of Agriculture. A third student, Chowdhuri Fateh-ud-din, sent by the same department, was admitted to a general course in agriculture from 18th August 1909.

Short courses in cattle breeding and management, poultry management, tillage implements, and agricultural machinery were given to some 15 students.

3. *Character of the Season.*—The rainfall for the season amounted to 72 inches, which is some 30 inches above normal. It was very badly distributed and was precipitated at times in such large quantities that the crops became injured. The result of the monsoon harvest was consequently a disappointment and the yields in no way approximated to expectation. The rain, too, was unusually heavy in the month of October, which not only retarded the preparation of the land for the *rabi* season, but caused unprecedented sickness amongst the labourers.

4. *Cropping.*—The trials with many varieties of sugarcane were continued as in previous years. In spite, however, of the care and control with which the cultivation and selection of this crop was carried out, the results were disappointing. It has been realised that the locality is unsuited to the growth of thick canes such as were being cultivated and with the exception of a small area reserved for the Mycologist and Entomologist the cultivation of this crop has been abandoned. Jute and flax have been grown for experiments for the Fibre Expert to the Government of Eastern Bengal and Assam with varying degrees of success. With regard to jute, the experiments were mostly for the purpose of determining the botanical characters in a collection of specimens. While this crop grows well in these districts, it is generally recognised that it does not do so well as in Eastern Bengal and its cultivation amongst the cultivators of Behar is not extending. With regard to flax, prospects appear promising provided the crop is grown in the best possible way, that is to say in strong land with an abundance of moisture. The work in this crop is being extended, and the experiments now in progress should solve most of the doubts and difficulties which prevent its being more generally adopted. In addition to the usual cultivation of rice carried out on the farm, the use of bone meal and saltpetre was tried in a series of $\frac{1}{4}$ acre plots. Two alternate plots were unmanured and the other two manured with 30 seers

of saltpetre and 3 maunds of bone meal per acre. The results were as under :—

	Mds	Seers.	
(1) Manured	30	17	per acre.
(2) Not manured	26	22	,,
(3) Manured	29	5	,,
(4) Not manured	26	4	,,

The result is slightly in favour of the manured plots, but the difference is not sufficient to warrant the expenditure. The remainder of the crops on the farm were grown mainly for the purpose of fodder for the increasing numbers of cattle. These crops consist chiefly of maize, sorgum, *arhar* (*Cajanus indicus*), and oats. A large number of varieties of crops in small plots were grown for the use of the Entomologist and Mycologist. The brick-field area, brought under cultivation for the first time, was sown with a mixed crop of rice, sorghum, and *moong* (*Phaseolus mungo*), and gave quite satisfactory results.

5. *Permanent Manurial and Rotation Experiments.*—These have been continued according to the scheme described in the Proceedings of the Board of Agriculture, 1908. Sufficient time has not elapsed for making deductions from these experiments.

6. *Permanent Pasture Experiments.*—The series of permanent pasture experiments laid down in the monsoon of 1907, according to the scheme described in the Proceedings of the Board of Agriculture held at Pusa in February 1908, has been maintained. The experiments aim at determining the effect of different manurial dressings (1) on the total yield of the herbage and (2) on its quality and botanical composition. So far as yield is concerned, it is much too early as yet to make any deductions, especially as the first two seasons during which the experiments took place were not normal with respect to rainfall. With regard to the quality of the herbage also, sufficient time has not elapsed for radical changes to have taken place. In fact, as the total number of species of grasses and legumes which were originally present was small, it is

scarcely to be expected that such complete alteration of the flora as has characterised similar experiments in Europe may be looked for in the case of Pusa. The condition of the plots at present may be summarised as follows :—

In the cold weather, they consist mostly of *Apang* (*Andropogon annulatus*) with a certain amount of *dubh* (*Cynodon dactylon*) and in the rains, of Digitaria and Rottboelia. At the end of the rains, the whole area is overgrown by *rari* (*Saccharum spontaneum*) and *dabhi* (*Imperata arundinacea*) which disappear entirely during the cold weather. The only legumes worthy of notice are *Medicago lupilina*, Linn., and *Indigofera linifolia*, Retz., both of which are " bottom " plants, useless for hay purposes. Weeds are practically a negligible quantity. On the whole, the composition of all the plots is as yet practically the same.

7. *Fodder.*—The supply of fodder for the cattle is one of the chief objects of the farm, and consequently by far the larger portion of the arable area is devoted to this purpose. Maize, sorghum, *arhar* (*Cajanus indicus*), and oats are the crops found most suitable. Ensilage is much resorted to, and if the process is properly carried out in silos of the American type, it is invariably a success. Maize probably gives the most nutritious food when thus prepared, but in point of yield per acre sorghum is more satisfactory and therefore more economical. The amount of silage made last year on the farm was 13,329 maunds.

8. *Breeding.* (*a*) *Cattle and Sheep.*—The Montgomery herd of cows continues to do well and its numbers have been increased. There are 62 cows, 3 bulls, and 108 young stock. The local herd of cattle which was maintained for the Bengal Government have been removed to Bettiah where they are being looked after by the Bengal Agricultural Department. This has given us more room for the extension of the Montgomery herd. The flock of 80 Bikanir sheep which were purchased two years ago have not done well. The change from an excessively arid to a humid tract caused a breakdown in their constitution and the

majority have died. The remainder will be got rid of, and in their place is being substituted a flock of Gorakhpur ewes which are good specimens of the local breed. These are at present doing well. It is intended to cross them with Dumbha rams with a view to improvement for mutton purposes.

(*b*) *Poultry Breeding.*—This work is now being conducted on a fairly large scale. The stock consists of 18 pens of fowls nearly all of pure breeds, one pen of Mammoth Bronze Turkeys, and one flock each of Embden Geese and Aylesbury ducks. The object is to supply at reasonable prices fresh blood of imported strains to Provincial Agricultural Farms and private individuals who are unable to afford the expense and risk of direct importation. This is effected either by egg distribution or by sale of birds. The price of eggs is Rs. 6 a dozen and birds are Rs. 30 for an adult trio and Rs. 16 for half grown birds. The eggs are sent by post or by rail in boxes specially made for the purpose, but it has to be acknowledged that this mode of distribution has not, by any means, been successful. The percentage of successful incubation from eggs transmitted by post or rail was extremely low, indeed so low that this method had to be discontinued. The failure is due doubtless to the fact that distances are so great in India, and the Postal and Railway authorities so unaccustomed to handling delicate articles like eggs, that the jolting and rough treatment in transit must have destroyed their fertility. The distribution of birds may be taken to have been altogether a success even in the case of long distances. The varieties of fowls which at present have done best are the Partridge Wyandotte, White Wyandotte, White Orpington, and Barred Plymouth Rocks. The Mammoth Bronze Turkeys have also done very well.

9. *Programme of work for 1910-11:*—1. *Permanent Experiments.*—The permanent manurial and rotation experiments and the pasture experiments will be continued.

2. *Extension of Botanical work.*—The growth of selected varieties of wheat will be taken up in extension of the

work now being done by the Imperial Economic Botanist. This work will be carried on in consultation with, and under the botanical surveillance of, the Imperial Economic Botanist.

3. *Cattle Breeding.*—The local herd has been transferred to the Bengal Agricultural Department and the Montgomery herd will now be considerably increased. Improvement of this breed by selection based principally on milk tests will be the chief object in view.

4. *Sheep.*—The crossing of Gorakhpur ewes with Dumbha rams will be undertaken.

5. *Poultry.*—Poultry breeding and distribution will be continued.

6. *Training.*—Courses in cattle breeding and the management of poultry will be given as heretofore.

REPORT OF THE IMPERIAL ECONOMIC BOTANIST, FOR THE YEAR 1909-10.

(A. HOWARD, M.A.; A.R.C.S.; F.C.S.; F.L.S.)

Part I.

Teaching, Training and Staff.—Two Supernumerary Botanists were in training during the year under review. Mr. G. P. Hector, M.A., B.Sc., the Economic Botanist-designate of Eastern Bengal and Assam, proceeded to that province on July 14th, 1909. Mr. E. Holmes-Smith, B.Sc., Supernumerary Botanist, worked at Pusa till February last when he proceeded to Bombay.

Five students attended the course on fruit growing and in addition, there were four students who attended special courses. One further short-course student was sent for a few weeks by the Economic Botanist to the Government of Bengal.

Mr. Ijaz Husain, Manager of the Lyallpur Farm, gave up his post in the Punjab Agricultural Department so as to become trained in this section as third assistant. My second assistant, Mr. Abdur Rahman Khan, has continued his training in Economic Botany in the section. I have pleasure in reporting the continued progress made by this assistant who, I believe, possesses real aptitude for and a thorough interest in Economic Botany. He is the joint author of an important memoir on some aspects of plant breeding in India recently submitted for publication.

While all other members of the staff have improved in their work, the services of my clerk, Ram Nechhawar Lal and of my second fieldman, Sarup Singh, deserve mention.

Part II.

Investigations.

Wheat.—I am able to report very considerable progress in the wheat investigations of this section along several lines.

The expectations foreshadowed in Pusa Bulletin No. 14 on the possibility of growing stronger wheats with better milling qualities than those now exported from India have been abundantly realised during the past year. A further set of Pusa selected wheats was sent to Mr. Humphries for milling tests. Several of these wheats were found to possess great strength and high milling qualities and to be of the same class as American and Canadian Spring wheats which command the highest prices on the English market. The results of this work are published in Pusa Bulletin No. 17.

The results obtained during the year on the influence of the environment on the quality of wheat have been submitted for publication as a memoir. This work, which is being conducted in collaboration with Mr. H. M. Leake, Economic Botanist to the Government of the United Provinces, has been greatly extended during the past year. While it has been proved that environment influences quality, the most practical outcome of this work is the discovery of the fact that the quality of any wheat depends largely on the proper and efficient preparation of the land and that canal irrigation does not necessarily injuriously affect the milling qualities of wheat. It is expected that great consequences will result from these investigations and that they will be the means of opening a new chapter in the production of wheat in India and in the agricultural practices of the Indo-Gangetic plain.

The Monograph on Indian Wheat has been published during the year. While going through the press, it was necessary to add a considerable amount of new matter so as to bring it up to date. The book represents the results of the preliminary work on wheat which has been done at Pusa during the last four years and will, I trust, be of use to students and some members of the Agricultural Department.

The investigations on the natural crossing of wheat in India have been written up and incorporated in a memoir.

It has been proved that under canal irrigation in the Punjab, crossing is exceedingly common, a fact which will render seed distribution and wheat breeding work at Lyallpur somewhat difficult.

Many of the new Pusa selections and also some of the new hybrid wheats were grown on quarter acre plots at Pusa this year. As no rain fell during the growing period and as no irrigation water was applied, the crop derived its moisture from the water stored up in the soil from the previous monsoon. The yields varied from 25 maunds in the case of early varieties to 35 maunds per acre in the case of the later sorts and some of the new hybrids. About 2·5 tons of straw to the acre were produced. These yields are unprecedented for India and were possible on account of the system of cultivation and dry-farming employed in the Botanical area at Pusa.

Fruit.—The results so far obtained in fruit-growing at Pusa have been published in Pusa Bulletin No. 16. A visit was paid to Quetta during the year and proposals have been put forward for developing the fruit investigations of the section.

Tobacco.—The results of the tobacco investigations have been published in two memoirs on the subject which form a basis for further work. Natural crossing is common in the crop but easily prevented by raising seed under bag which gives rise to uniform crops. Some preliminary curing experiments have been conducted in conjunction with the Peninsular Tobacco Company with both American and Indian varieties. The Pusa varieties have given the best results so far.

Fibres.—A good deal of work has been done on *Hibiscus cannabinus*, but I have been unable to find time to write up the results. A memoir on *san* (*Crotalaria juncea*) has been published in which the beneficial effect of this crop as a green manure for tobacco has been described.

General.—A large amount of work on the occurrence of natural cross-fertilization in India has been written up

as a memoir and submited for publication. The significance of this work both from the point of view of plant breeding and from that of seed distribution has been emphasised.

Programme of work for 1910-11.—1. *Training.*—The training of advanced students in this section will be continued on the lines laid down in the prospectus of the Institute. The course on fruit-growing will be given as usual in the cold weather.

2. *Plant breeding and plant improvement.*—During 1910, the following crops will be studied :—wheat, tobacco, barley, oilseeds and fibre plants.

(*a*) *Wheat.*—The botanical survey of the wheats of Baluchistan will be completed. The production of improved varieties by selection and hybridization will be continued. The co-operative experiments on the effect of environment on the milling and baking qualities of Indian wheats, which are being conducted in collaboration with Mr. H. M. Leake, Economic Botanist to the United Provinces, and of which the earlier results are now in course of publication, are being continued on an extended basis. The above experiments include the effect of weathering on the quality of the wheat crop and the Imperial Bacteriologist has agreed to undertake the study of the bacteriological aspect of this subject.

(*b*) *Tobacco.*—The production of new varieties by selection and hybridization will be continued as well as the testing and curing of the varieties already isolated. The investigations on the influence of environment on the stability of the type and on the quality will continued.

(*c*) *Oil-seeds.*—The study of the oil-seeds of India will be continued on similar lines to those adopted in the investigations on wheat.

(*d*) *Fibres.*—The isolation and testing of pure races of the fibre plants of India will be continued.

(*e*) *Fruit.*—The fruit experiments will be continued on the lines laid down in the First Fruit Report.

(*f*) *Minor Investigations.*—The study of the varieties of cassava will be completed and the investigation on the inheritance of sex in *Ganja* continued.

Publications.—The following books and papers have been published and written during the year :—

Report on Economic Botany for the Board of Scientific Advice, 1909 (in the press).

The Milling and Baking Qualities of Indian Wheats, No. 2. Some new Pusa Selections tested in 1909 (with G. L. C. Howard). *Bulletin No. 17 of the Agricultural Research Institute, Pusa.*

Second Report on the Pusa Fruit Experiments, *Bulletin No. 16, Agricultural Research Institute, Pusa.*

The Fertilising Influence of Sunlight (with G. L. C. Howard). *Nature*, February 17th, 1910.

Studies in Indian Tobaccos. No. 1. The types of *Nicotiana rustica* L. Yellow-flowered tobacco (with G. L. C. Howard). *Memoirs of the Imperial Department of Agriculture* (*Botanical Series*), Vol. III, No. 1.

Studies in Indian Tobaccos. No. 2. The types of *Nicotiana tabacum* L. (with G. L. C. Howard). *Memoirs of the Imperial Department of Agriculture* (*Botanical Series*), Vol. III, No. 2.

Studies in Indian Fibre Plants. No. 1. On two varieties of *Sann, Crotalaria juncea*, L. (with G. L. C. Howard). *Memoirs of the Imperial Department of Agriculture* (*Botanical Series*), Vol. III, No. 3.

The Influence of the Environment on the Milling and Baking Qualities of Wheat in India. No. 1. The results of 1907-08 and 1908-09 (with H. M. Leake and G. L. C. Howard). *Memoirs of the Imperial Department of Agriculture* (*Botanical Series*), Vol. III, No. 4.

The Economic Significance of Natural Cross-fertilization in India (with G. L. C. Howard and Abdur Rahman Khan). *Memoirs of the Imperial Department of Agriculture* (*Botanical Series*), Vol. III, No. 6 (in the press).

Wheat in India, its varieties, production and improvement (with G. L. C. Howard). Published by Thacker, Spink and Company, Calcutta.

REPORT OF THE IMPERIAL AGRICULTURAL CHEMIST, FOR THE YEAR 1909-10.

(J. Walter Leather, Ph.D.; F.I.C.; F.C.S.)

Charge of Section.—Mr. H. E. Annett, B.Sc., M.S.E.A.C., Supernumerary Agricultural Chemist, was in charge of this section until October 27th when I returned from leave.

Meteorology.—In addition to the usual temperature, humidity, etc., records, an evaporimeter has been constructed and the data will prove of service to both the Meteorological and Irrigation Departments. The first instrument employed, a self-recording one, proved to be defective, chiefly because the atmospheric dust of the hot weather accumulated in the working parts. A much simpler and quite reliable instrument was kindly supplied to me by the Chief Engineer, Punjab Irrigation Branch, and reliable data can now be obtained, though the record is not self-maintained.

Drainage data.—The records of drainage under conditions of both bare-fallow and cropped soil at Cawnpore and Pusa are now bearing fruit and the first few years' results will be put together for publication at the close of the present monsoon. In addition to the quantities of water which percolate, evaporate or run off the land respectively, information regarding the period of most active nitrification, as also the effect of crops on nitrification is being gleaned. This subject is not entirely novel, M. Dèherain having published information in respect of it some 15 years ago, but it has not generally been acknowledged as important. The crops, wheat and maize, which were grown on two of the Pusa gauges, depressed in some way or other the formation of nitrates last year very materially.

Water requirements of crops.—The first section of this investigation was published during the year as Memoir

No. 8, Chemical Series, and dealt with both the total amount transpired as also the period during which the greater part was assimilated. The effects of temperature and humidity, proportion of water in the soil, manure, the nature of the crop, etc., were dealt with. One of the most important of these is manure, which whilst increasing the weight of the crop and consequently the amount of water required, effects an economy of the latter since the increased requirement of water is proportionately less than the increase in crop. Good tillage probably has a similar property. The second section of the investigation has to do (*i*) with the effect of different soils and (*ii*) with the results of field tests; this will be published shortly.

Soil Gases.—The first section of work in connection with the subject of soil gases dealing with the relations of carbonic acid to calcium carbonate and water, has been published as Memoir No. 7, Chemical Series, and it is expected that a second section dealing with the similar relations to magnesium carbonate will be published in the course of the cold weather.

Usar land.—At the request of the Deputy Director of Agriculture, Central Circle, United Provinces, an investigation into the nature of some land which has been going out of cultivation in the Mainpuri District, has been commenced and has indeed absorbed so much time that no less than three or four of the assistants are at present utilised for it.

The soil is Usar, of the "black alkali" type, but the amount of alkali present was thought at first to be too small to account for the sterility. The sub-soil water level has risen seriously of late years and no doubt was felt that this was one of the primary causes of the trouble. But in addition to this, preliminary tests showed that the soil is so highly impervious to water that this feature alone might account for sterility. All, or at least nearly all, the water assimilated by plants must move through a certain amount of soil before it comes in contact with the root; such distances may only be a few inches or centimetres,

but this feature of the process must nevertheless be recognised; and if the amount of water moving to the root in a given time is too small for the nourishment of the plant, there may be abundance of water in the soil, and yet unable to reach the roots sufficiently quickly; the plant's energy would thus become reduced, and the crop might die off altogether.

There were thus three distinct questions involved, namely, (*i*) the high sub-soil water level, (*ii*) the alkali in the soil, and (*iii*) the impervious nature of the soil. The investigations which are being conducted at Pusa have to do with Nos. (*ii*) and (*iii*) of these questions.

In order to study the subject in the field as far as possible, Mr. S. C. Kar, M.A., the second assistant, was deputed to work under the instructions of Mr. B. C. Burt, Deputy Director of Agriculture, United Provinces, at Bhadan, where a temporary laboratory was fitted up. Here the amounts of alkali and water were determined in the soil at specific points, in every 6 inches depth down to 7 feet or 8 feet from the surface, until the middle of May, when this part of the work was transferred to Pusa. In addition to an estimate of the amount of salts in these soils, it was especially desired to ascertain the amount of their upward movement during dry weather or their downward movement during the rains. But since no two tests can be taken in exactly the same place and since further it is known that the amounts of such salts vary considerably within comparatively short distances in the lateral direction, it became necessary to determine this latter, as an adjunct to the former feature. Such an investigation involves more work than might appear necessary at first sight and the whole series of tests are not yet complete, but it has become abundantly evident that (*i*) the amount of variation laterally is, as was anticipated, comparatively large, and (*ii*) that in these soils the amount of upward movement of salts to the surface during the dry weather is only nominal. This latter feature is quite in accord with expectation; the amount of salts brought to the surface

will depend largely on the amount of water moving upward; if the soil is highly impervious to water, such movements will be very limited; and consequently the amount of salts brought to the surface must likewise be limited. There was hardly any upward movement of water, and accordingly there could be no material concentration of salts at the surface.

The soil being so highly impervious to water, it became of first importance to try to measure this characteristic. By an improvement of a method originally suggested by Mr. Milton Whitney of the United States Department of Agriculture, a mechanical test has been devised, by the aid of which very interesting information has been obtained regarding the rate at which water can move through the Mainpuri as also through other soils. Thus for example, the Usar land in the Mainpuri District which we have been examining, is highly impervious as far down at least as the samples were drawn; the Juhi Usar reserve near Cawnpore is similar to a depth of 5 feet after which it is quite pervious to water; other sterile spots of land have proved to be quite pervious to water, and their sterility must be due to other causes.

In addition to these lines of investigation an exhaustive series of pot-cultures has been commenced at Pusa in order to ascertain whether the defective physical state of the Bhadan (Mainpuri) Usar soil can be remedied or reduced; and if this change were effected, whether the amount of alkali is itself sufficient to cause sterility; also what plants will grow most readily under such adverse conditions.

Finally, in addition to work on the Bhadan soil, the Usar land which has been wholly or partly reclaimed near Aligarh, by the Department and by Mr. Keventer respectively, is being examined in order to ascertain what changes have taken place during the period of years that the work has been in progress.

General Analytical Work.—The number of samples sent for analysis has remained, as in the preceding year,

much smaller than it formerly was. Most of the Provincial Departments are now able to execute all such work for themselves, and assistance in this respect has only been asked for from three provinces. The major part of the remaining samples has been submitted by the officers in charge of the Military Farms, who require opinions on soils and on grasses and other feeding stuffs.

Education.—One student from the Punjab took a short elementary course of Chemistry. One of the assistants of the Agricultural Chemist, United Provinces, is taking a three months' course. In addition, two new assistants on the ordinary establishment have been entertained, and these, as in all such cases, have been largely in the position of students.

Establishment.—The changes involved have been due (*i*) to a junior assistant not being confirmed and another appointed in his place, and (*ii*) to the temporary appointment of a graduate of the Bombay University to act during the absence of other members of the regular establishment. The latter case is of interest, because although this assistant is an M.A. graduate with very good credentials, he was willing to come for a purely temporary acting appointment on Rs. 50 and thereby try to learn something. The other assistant who was appointed during the year, worked purely as a volunteer for about a year in Mr. Hooper's laboratory at the Indian Museum, and has proved an excellent assistant. It is this class of man that deserves most encouragement and likewise generally makes the best public servant; young men who are willing in the first instance to show that they are capable of doing useful work rather than to sit down and do nothing until a highly paid appointment turns up.

Programme of Work for 1910-11.—1. The work on the availability of plant food in soils will be continued, the immediate aim being the more correct ascertainment of the composition of the aqueous solution in the soil. Included in this section of investigation are naturally the amounts of nitrate in soils and soil temperatures.

2. The investigation on soil moisture and water requirements of plants is being continued on lines which have been sufficiently indicated in the memoirs.

3. A joint investigation with Mr. Burt, Deputy Director of Agriculture, United Provinces, is being conducted into the causes of infertility in a tract of land in the Mainpuri District.

4. The effect of soil and manure on the composition of crops is a branch of study which is engaging the attention of a number of investigators and is one on which I have already obtained some information. It will be developed, if possible, at Pusa during the coming year.

5. Two points in relation to the Indian saltpetre manufacture, in respect of which it seems possible that an improvement can be suggested, will be investigated.

6. *Education.*—This requires no special comment; it will be conducted according to the lines laid down.

Publications.—The following papers have been published :—

Memoir No. 8, "The Water Requirements of Crops in India" by Dr. J. Walter Leather.

Memoir No. 9, "The Nature of the Colour of Black Cotton Soil" by Mr. H. E. Annett.

REPORT OF THE IMPERIAL ENTOMOLOGIST, FOR THE YEAR 1909-10.

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

Charge and Establishment.—The Imperial Entomologist held charge of the section during the year. The Supernumerary Entomologist, Mr. C. W. Mason, left the Department on December 19th and Mr. T. Bainbrigge-Fletcher, R.N., F.E.S., joined the Department as Supernumerary Entomologist on the 8th April. The first assistant, Mr. C. S. Misra, who has absent on privilege leave from the 4th May to the end of June, had charge of the students, of the field-work on the Pusa Farm and Botanical area and of the work with lac culture. Apart from the courses of lecturing given by the Imperial Entomologist personally, Mr. Misra has carried out the field and practical instruction of students, which he has done admirably, and also one of the two short courses of instruction given in lac culture. The second assistant, Mr. C. C. Ghosh, has had charge of the insectory and carried out all inquiries conducted there. His work has been of the very greatest utility; he has also been able to prepare a Bengali revision of Indian Insect Pests which has been published. The third assistant, Mr. G. R. Dutt, who was absent on privilege leave from 1st November 1909 to 31st January 1910, has been in charge of economic records, correspondence and collections and has done original work on *Aculeate Hymenoptera*. In spite of his heavy routine work he has found time for both original enquiry and for the compiling for publication of a list of the vernacular names of insects, which is being published. Mr. D. Nowrojee has been in charge of the general collections and has done excellent work in their upkeep and arrangement. The post of Sericulture Assistant, which was filled up by Mr. L. M. Dass, is now held by Mr. R. R. Ghose. The Bengal Entomological Assistant worked in the laboratory for some

months, pending the provision of accommodation at Sabour; the artist staff of the Institute also worked under the direction of the Imperial Entomologist from September to January. The Baroda Entomological Assistant spent a fortnight in Pusa discussing his year's work and the programme for next year.

Training.—The full course of Entomology was given to students from Madras, Central Provinces, Bengal and the United Provinces. It is to be regretted that no students have been sent for the course commencing on June 1st, 1910. A short training, as part of the course in general agriculture was given to a student from the Punjab. The short courses in Eri Silk cultivation have been taken up by 15 students from different parts of India and by boys sent by the United Provinces Agricultural Department. Irregular training in rearing has been given to a number of rearers from Indigo factories, zemindars, etc., who were taking up the industry. The courses in lac have been taken up by 10 students from Lucknow, Hyderabad, Bettiah, Dacca, Cuttack, Jullundur, Rajkot, Jodhpur and Gaya and three *malis* were trained for employment in lac-work in Behar.

Provincial work.—The number of assistants employed in Entomological work in the Provincial Agricultural Departments is now 16 : 5 for teaching, 11 for field work. This number is wholly insufficient to bring the practical work of Entomology before the agricultural classes, but in the absence of Entomologists in the Provincial Departments to direct their work, the number is not being increased. It is something that applied Entomology forms part of the course of training at five Agricultural Colleges, but it is too much to expect eleven field-assistants to make any progress with showing how crop pests can be checked. As in previous years, the assistance offered in directing and checking the work of these assistants has been utilised by some provinces and the more technical work has been referred to Pusa, leaving the assistants free to do field work entirely. In Madras, the study of the destructive insects

has been continued on the lines laid down in 1906, and very substantial progress has been made; the pests have been carefully studied in almost every district and the preliminary work of collecting information on the spot materially advanced. Good work has been done against the Hairy Caterpillar pest in South Arcot and against the Deccan Grass-hopper which appeared in the Northern Division. In Bombay, very successful work has been done against the Rice Grass-hopper; the Potato-moth and Deccan Grass-hopper are being worked at where they occur and the work should bear fruit this year. Proposals have been made for putting the Entomological work on a better footing and placing it under the general direction of the Imperial Entomologist as in other provinces. In the Central Provinces, the success of the methods tried against Potato-moth has led to their adoption on a larger scale and a careful trial has been made of the trap-crop method of checking boll-worm of cotton on the farms. The cultivation of Eri silk has been experimentally taken up at Multai and Chanda. An investigation into termites in Hoshangabad has been started with the Deputy Director of Agriculture, Northern Circle, and the general pests of the province are being investigated. In Bengal, and Eastern Bengal and Assam, the general investigation of injurious insects has been continued; in the latter, the work against Potato-moth is likely to give good results. In the United Provinces, the work against the Cane Grass-hopper has been the principal item and the general investigation of injurious insects has been continued. The cultivation of Eri silk has been experimentally taken up at Cawnpore. In the Punjab, sericulture and bee-keeping have been experimented with and the general crop pests of the province investigated. In Baroda, good work has been done in inducing cultivators to take an interest in and adopt measures against the Hairy Caterpillar, the boll-worm and the *til* stem-borer, in addition to the usual cases of insect pests reported from various crops.

In general, the provincial work is preliminary and directed to ascertaining what are the pests of the province and how far they are destructive. Only in Madras is the work so far advanced that an accurate statement of the crop-pests can be prepared and a reasonable estimate formed of the possibilities of developing the work. In almost all provinces, progress has been made in coping with crop-pests as they occur in serious outbreaks, but in almost all the work requires systematising on a permanent basis that will conduce to steady progress and eventual thoroughness. Much advance cannot be achieved while the present staff in the provinces is limited to eleven assistants and the direction of the work is in the hands of various officers in the Provincial Departments who have other work to do and who do not want additional staff to look after.

Correspondence.—As in previous years, there has been a large volume of enquiries on all matters connected with insects; the enquiries connected with insects attacking crops have been mainly diverted to the Provincial Departments, but a large mass of miscellaneous enquiries has been received and dealt with. A part of these are from official sources, exclusive of the correspondence with Provincial Agricultural Departments, but a large part also is from the general public; they deal with garden and fruit pests, household pests, insects in grain and timber, insects on domestic animals, insecticides, spraying machines and the identification of insects. The parcels of injurious insects sent in numbered 117. A total of 1,255 enquiries came from official and public sources and at least as many again from planters and others in close touch with the section were answered demi-officially without record. The enquiries with regard to si'k numbered over 1,000 and there were many concerning bee-keeping and lac. So far as possible, these are answered by reference to publications, or by the despatch of a leaflet or reprint but they are of such wide range that a very large number must be answered fully and this occupies much time. I hold this work to be of very direct value and I believe every enquiry has been fully and promptly met to the best of our ability.

Research.—Progress has been made with enquiry into the life histories and habits of injurious insects. The more important have been the Palm-weevil, and Rhinoceros beetle, the Army worm, the Rice Swarming Caterpillar, the Deccan Grass-hopper, the Wheat Stem-borer, the Pink Boll-worm, the Indigo Leaf-webber, the Dusky Cotton Bug, Wheat weevil, Rice grain moth. A more careful enquiry into the white ant problem has been commenced partly at Pusa, partly at Hoshangabad in conjunction with the Deputy Director of Agriculture, Northern Circle, Central Provinces. In collaboration with the Imperial Agricultural Chemist, the enquiry was continued into the relation between weevil and the percentage moisture of wheat. The enquiry into the food of birds by Mr. C. W. Mason was brought to a conclusion and the results will be published. The new insecticide was thoroughly tested and is now on sale. An increasing number of patent insecticides have been referred here for trial and report; these have been tested and, with the check afforded by the analysis of the Imperial Agricultural Chemist, reported on as to their value for Indian conditions. Only one has proved to be of any value for this country and, with this exception, the insecticides introduced by this Department are those at present in use; arrangements are made for their sale and we maintain a register of the places where both insecticides and all patterns of spraying machines can be purchased, so that enquirers can be at once referred to the proper places. Until private enterprise finds this business worth taking up, the trial of insecticides and sprayers must be done here and arrangements made for their sale. The question of apiculture is still being considered and further attempts are being made to determine how far bees will thrive and be profitable in the plains.

Sericulture.—The cultivation of Eri silk was continued and all processes to the production of the finished cloth carried on. Three weavers, an average of twelve spinners and cleaners, and about fifteen rearers are constantly

employed and we endeavour to produce every variety of cloth that is likely to be made of this material. The course of training was given to 19 persons, mainly those who wish themselves to take it up as an industry or the employees of those who are commencing the industry. The Pusa Continuous Spinning Machine was perfected and arrangements made for its sale. Assistance was given to the inventor, Mr. R. W. Coryton, of a very ingenious machine for cleaning the cocoons prior to spinning and this machine is now being sold. Every process from rearing the worms to weaving the cloth is being conducted in the silk house, so that visitors can see and quickly understand the whole process. The demand for seed has been very large (in one month $2\frac{1}{2}$ million eggs were sent out) and arrangements were made for an exchange of seed between rearers in different parts of India, this section being the medium for effecting the exchange. Seed was supplied from Pusa to as many persons as possible, but the demand was far in excess of what could be supplied. Many hundreds of persons have given a trial to the industry and while many have, for the present, stopped owing to the absence of any means of disposing of small quantities of cocoons, many are continuing successfully. No attempt was made by this section to popularise or to draw attention to this industry except in Tirhoot, with the sole exception of the publication of an article in the Agricultural Journal of India; yet hundreds of enquiries have come in, from every part of India except Assam, and it is evident that, if there was the organisation to help, advise and buy small lots of cocoons, the industry could be taken up on a very large scale, affording light remunerative work to women and children which they take to readily. In Tirhoot, an attempt was made to induce the Behar Indigo Concerns to serve as buying centres for the hundreds of small lots of cocoons that were being offered but this has failed. Many Tirhoot rearers are still carrying on the industry in order to make and sell cloth but at the commencement all small rearers want to sell cocoons. The industry is establishing

itself, as centres for buying cocoons develop naturally and as the rearers take to making cloth. It is evident that the larger land-owners must take it up first and that the small cultivators cannot do so without some organisation to dispose of their products. It is also necessary at first to be in touch with Pusa or some other centre that can advise and help. The industry is most extensive at present in Tirhoot, Bhagalpur and Patna, the three divisions nearest to Pusa but is being tried also in Malabar, Dharwar, West Coast, Gujarat, Kathiawar, Sind, Patiala, Rohilkhand, Betul, Chanda and Murshidabad. The Salvation Army has also taken it up at Bangalore and elsewhere. Enquiries were made from silk spinning firms in England, France, Switzerland and Japan as to the value of Eri silk cocoons for industrial use there; one Indian silk spinning mill is spinning Eri silk yarn of fine counts, which is being used for weaving in India; but until there is some organisation for collecting and selling large quantities of cocoons, the industrial uses of this material cannot be developed. In this question, we have had the assistance of Mr. Drieberg of the Ceylon Agricultural Society, who is interested in the same problem. Trials are being made at Pusa with hybrids between *Attacus ricini*, the Eri, and *Attacus cynthia*, the wild form; these are not encouraging but may yield a more robust race. The disease of Eri worms which is occasionally a serious and inexplicable factor, is being investigated in collaboration with the Imperial Agricultural Bacteriologist and trials are being made of the various varieties of castor for feeding the worms.

Mulberry silk cultivation was continued mainly to determine how far it can be profitably taken up either to provide raw silk, or to supply cocoons. All available varieties have been collected at Pusa for hybridising. The rearing of the best Italian and French varieties has been very successful; the rearing of the ordinary Bengal varieties has shown that they are not worth cultivating in Behar, and the cultivation of a hybrid between the European univoltine worms and the Bengal multivoltine is

giving good results. The problem of increasing the supply of good cocoons for reeling is of very great importance and there is good reason to believe that very much better cocoons could be produced on a large scale if the industry were developed on the right lines. The experiments of the Bengal Silk Committee and those carried out at Pusa show that success is probable, but that it will take time and organisation to develop the supply and keep rearers on the right lines; failure in inevitable if the present Bengal varieties are cultivated as the silk is almost unsaleable and not worth growing and reeling in new localities. The present experimental work is very satisfactory and the very depressed condition of the silk industry fully justifies the employment of a proper staff to complete and develop these lines of improvement.

Lac.—The cultivation of the lac-insect on *Ber* (*Zizyphus Jujuba*), *Siris* (*Serissa alomeruta*), etc., has been carried on as before and two short courses of training were given to ten students from Bengal, Hyderabad (Deccan), the Punjab, the United Provinces, Kathiawar and Jodhpur, as well as to *malis* from factories in Tirhoot. Lac for seed was supplied to the Bombay and Baroda Departments of Agriculture, to a Court of Ward's Estate in Orissa and arrangements have been completed for forwarding the same to Formosa through the Japanese Consul at Bombay. The most important work of the past year was an enquiry into the races of the lac insect in collaboration with the Forest Department which sent in samples from all parts of India and Burma. The samples are being collected, arranged and forwarded to Mr. E. E. Green, the Government Entomologist, Ceylon, for examination. The number of enquiries regarding lac cultivation in India increased considerably and every assistance was given to those wishing to start it on waste lands in agricultural areas.

Demonstration.—The series of coloured plates of pests has been added to and copies circulated to all Provincial Departments, to the Bombay Natural History Society, the Quetta Museum, the Madras Museum, the Bishop Cotton

School, Simla, the Indian Gardening Association, Calcutta, the Central Agricultural Committee of Madras, the Ceylon Agricultural Society, Colombo, Department of Agriculture, Baroda State, Mycologist and Entomologist, Mysore State and the Director, Educational Section, United Provinces Exhibition, Allahabad. These plates are being utilised in demonstration in all provinces and in vernacular and other publications in Bengal, Eastern Bengal and Assam, Bombay, the United Provinces and the Central Provinces. They are also used in preparing show cases of crop pests for exhibitions, shows, farms, etc. Sample show cases have been prepared and sent out; all Entomological Assistants have been trained in preparing them and it is now only necessary to complete the series of plates to cover all crop-pests, beneficial insects and such useful insects as silk, lac and bees. Trials are being made of coloured lantern slides of these plates to enable lectures to be given at agricultural shows, etc. Assistance was given in preparing show-cases and exhibits for the agricultural section of the Lahore Exhibition and a working exhibit of Eri and mulberry silk was sent to the Muzafferpur Exhibition.

Insect Survey.—Less time has been given to the work with the general collection, only new accessions being placed and arranged. The students' working collection has been very much added to. Collections have been sent away for the use of authors of coming volumes of the Fauna of India. These include the *Collembola*, *Orthoptera*, *Mallophaga*, *Braconidæ* and *Ichneumonidæ*, *Neuroptera*, *Odonata*, *Dynastidæ*, *Rutelidæ* and *Cetoniidæ*, *Cantharidæ*, *Curculionidæ*, *Microlepidoptera*, *Thysanoptera*, *Rhynchota*, *Heteroptera* and *Homoptera*. Further collections were identified and arranged for the Bombay Natural History Society, and specimens were identified for private collectors, for the Madras Museum and the Quetta Museum. Similar collections were made up and identified for Provincial Agricultural Colleges and a large mass of identified material is available for distribution.

Miscellaneous.—The Imperial Entomologist is President of the Entomological Section of the Bombay Natural History Society and lectured to the Society in September. All entomological enquiries sent to the Society are referred to him and insect specimens sent in for identification are referred to Pusa. The Imperial Entomologist also acted as Chairman of the Indian Sub-Committee of the International Congress of Entomology to be held at Brussels in 1910. An exhibit illustrating the work of the section was sent to the delegate for India, Mr. F. M. Howlett, Second Imperial Entomologist. Assistance has been given to the Government of Japan in regard to Eri silk and lac and the latter insect is being introduced into Formosa. The improvements made in the treatment of Eri silk have been communicated to the Ceylon Agricultural Society. Parasitised cotton boll-worms were sent to Ceylon and Egypt to introduce the parasite; live Eri cocoons were sent to Ceylon, China and Formosa, and live tussur cocoons to Egypt; Eri cocoons were also sent to England and France, the former in order to be crossed with *A. cynthia*, to improve the race. In exchange, *cynthia* cocoons were received at Pusa for the same purpose.

Programme of work for 1910-11.—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 shows. Assistance is being given in the entomological exhibits at the Allahabad Exhibition. The issue of coloured plates is being continued and coloured lantern slides for lectures will be issued for trial. Further work on apiculture will be done and the short courses of instruction in Eri silk, mulberry silk and lac continued. The progress of the Eri silk industry will be assisted specially with a view to finding foreign markets and to the using of the material for products required in India. The question

of growing better races of mulberry silk for supply to the Bengal filatures will be further tested and the general question of improving the silk industry investigated.

Publications.—The edition of Indian Insect Pests is exhausted and the progress for the last four years makes a new edition necessary. A revision up to June 1909, has been translated into Bengali by the second assistant, Mr. C. C. Ghosh, and published in Calcutta. Applications for permission to publish other translations have been referred to the respective Provincial Departments as a revision of the text is required and the staff at Pusa cannot translate into all vernaculars. "Indian Insect Life" has been issued and is now available for all students and workers in Entomology. A list of other publications is attached. This is smaller than it might be, but the time has not been available for preparing more and the issue of these has entailed much work that should not fall on the staff of this section.

PUBLICATIONS.

Indian Insect Life. (Text-Book.) September, 1909.
Fasaler Poka. (Text-Book.) September, 1910.
Lac as an Agricultural Product. (Agri. Journ. Ind.) July, 1909.
A New Insecticide. (Agri. Journ. Ind.) April, 1910.
Weevil in Wheat. (Indian Trade Journal.) November 18, 1909.
Fauna of Tirhoot I. Rhynchota. (Ind. Mus. Records.) December, 1909.
Storage of Potatoes. (Agri. Journ. Ind.) January, 1910.
Thrips in Tea in Darjeeling. (Agri. Journ. Ind.) July, 1909.
Instructions for rearing Eri Silk. (Leaflet in English, Hindi, Bengali.) January, 1910.
Eri Seed Exchange. (Leaflet.) January, 1910.
Life-Histories of Coleoptera. (Memoir.) January, 1910.
Vernacular Names of Insects. (Bulletin in press.)
Tukra Disease of Mulberry. (Agri. Journ. Ind. and Bengal Agricultural Journal.) April, 1910.
Three Journal Reviews.

REPORT OF THE IMPERIAL MYCOLOGIST FOR THE YEAR 1909-10.

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

Charge and Establishment.—Mr. W. McRae, M.A., B.Sc., Supernumerary Mycologist, held charge of the Section until December 27th, 1909, when I returned from leave. Mr. McRae joined his new appointment as Mycologist to the Government of Madras immediately after; his loss was much felt, but he has taken charge of mycological work in a province which is second to none in India in the number and magnitude of its fungus diseases of plants. His successor, Mr. F. J. F. Shaw, B.Sc., A.R.C.S., joined his appointment on January 28th, 1910. The vacant post of first assistant was filled by Mr. J. F. Dastur, B.Sc., on May 14th, 1910. Mr. J. H. Mitter, second assistant, was appointed Assistant Professor of Mycology in the Punjab Agricultural College, Lyallpur, from June 1st, 1910. The remaining members of the laboratory staff have each received promotion as a consequence. All have done good work. Messrs. J. H. Mitter and S. N. Mitra have given material assistance in the training of students and in general laboratory work; the latter, Mr. A. Hafiz Khan and Munshi Inayat Khan in field work and on tour; while Mr. Hafiz Khan, by his keenness and capacity for independent research is proving a valuable assistant. In Munshi Inayat Khan we have one of the most useful types of native botanical assistants; without any English education, he has yet an almost phenomenal knowledge of indigenous plants gathered during long service under Mr. Duthie in the Saharanpur Herbarium and as a collector in all parts of Northern India. He is in charge of the herbarium and collections, which are well kept up. The Bengal Mycological Assistant worked in the laboratory pending the provision of accommodation for him at Bhagalpur, until April 14th, 1910.

2. *Training.*—Nine students in all received instruction during the year. Of these two were second year students undergoing the full course. Their training ended on March 31st, 1910. Three were members of the Punjab Agricultural Department and received elementary instruction as part of a general agricultural course. As the Provincial Colleges are now in a position to teach elementary mycology, it is not expected that any more students of this class will be received. The student under training as Mycological Collector for Eastern Bengal finished his course on March 2nd, 1910. A Forest Ranger was deputed from the Punjab for an elementary training in the diseases of fruit and forest trees, and a private student from Oudh received a short course in fruit and vegetable diseases. Only one student (private) joined for the full two years' course at the beginning of the new term, June 1st, 1910, and he has since abandoned it. The three senior students took up about half my time in January, February, March and June, chiefly in the preparation of the lectures.

3. *Accommodation.*—The capacity of the general laboratory for students and assistants has been taxed at times, especially when several have been simultaneously engaged in original work. For a time eleven were working in the one room, which is too many for the space available. A portion of the clerk's room has been fitted to relieve pressure in the laboratory. The chief requirement at present is a small outside room with enclosure attached for inoculation and pot-culture experiments. The herbarium has been largely added to (364 named sheets), and has ample space for subsequent expansion in a room on the 1st floor. Improvements were made in the sterilising and culture rooms.

4. *Aid to Provincial Departments.*—Collections of named fungi, chiefly parasitic, have been furnished to the Madras, Punjab, Bengal and Eastern Bengal and Assam Departments. Duplicate collections made in Bombay and Burma have been identified as far as possible and the determinations forwarded to these Departments. This work

will be continued so as to provide a nucleus for a mycological herbarium in every provincial college. The detailed syllabus for an elementary course of lectures and practical work in Indian Mycology, drawn up last year, is being utilised as a basis for the mycological instruction in several colleges. The recommendation of the Board of Agriculture of 1908, that each province should have at least an Assistant Professor of Mycology and one other assistant is being worked up to fairly well. Besides Madras, which has now its own Mycologist, Mr. McRae, with one scientific assistant, Bengal, Bombay and the Punjab have each an Assistant Professor of Mycology attached to its college, the two former having a Mycological Assistant as well. The Central Provinces College has a Mycological Assistant, and Eastern Bengal a Mycological Collector. All these, except the Bombay Assistant Professor, have been trained at Pusa.

5. *Research Work. Blister Blight of Tea.*—This was the most important new work taken up during the year. The disease, which has been known for years in North-East Assam appeared for the first time in Darjeeling in 1908. In 1909 it extended, and the Darjeeling Planters' Association asked for the assistance of Pusa. Mr. McRae spent a considerable time in a local investigation of the blight. The life-history of the fungus (*Exobasidium vexans* Massee), before imperfectly known, was fully worked out and an extensive series of experiments on remedial measures undertaken. As a result of these, definite recommendations were made for the cold weather of 1909-10 and general measures for the control of the blight advocated. The results of the work were communicated in two reports to the Darjeeling Planters' Association, by which body they were printed for circulation to the planters concerned. In the present season, the blight is continuing to spread and already threatens the Dooars and Terai. Its progress will be watched with great anxiety by all interested in tea. It is feared that the climatic conditions prevalent in these districts will induce

greater virulence than anything known in Assam, but this will not be known with certainty until the close of the present or perhaps another season. A popular account of the disease is given in the Agricultural Journal of India for April, 1910, and a fuller report is in the press as a bulletin.

Other Tea Diseases.—Mr. Shaw is engaged in the study of the obscure canker of tea, which has long been known but the cause of which is still not ascertained. A disease of tea seed was investigated, but the cause was not definitely discovered.

Palm Disease.—The campaign having as its object to prevent the spread of the bud-rot of palms on the East Coast and to stamp it out within the affected area was prosecuted with energy by the executive officer in charge, Mr. W. K. Green, Special Deputy Collector, Godavari District. I accompanied Mr. McRae, to whom the scientific control has now passed, and Mr. Green on a short tour of inspection early in the present year. Recommendations for continuing the work have been made, especially for its energetic prosecution in Kistna District, where it has been neglected in spite of repeated warnings. Mr. Green was put in charge of work in Kistna as well as in Godavari from January last and this led to better work. A full account of the disease and measures taken to check it is in the press as a memoir. Mr. McRae enquired into a disease of palms at Bapatla in December but found it was not fungal. The coconut root disease in Travancore mentioned in last report is engaging the attention of the newly started Agricultural Department of that State, and measures have been taken on the lines suggested to prevent its spread. The cultivators of neighbouring districts have been warned through vernacular pamphlets of the danger of introducing certain coconut produce from Travancore.

Sugarcane Diseases.—The work in connection with these has not yet reached the stage of publication. Field experiments on the methods of infection of red rot having developed unexpected difficulties, it will probably be neces-

sary to continue in pot culture. Nothing has occurred to shake the opinion advocated by this section that it is primarily a disease conveyed in the sets and it is encouraging to report that scarcely a trace of it could be found at Samalkota Farm in the last crop. Similarly at Pusa there is ordinarily little, except near where the inoculation experiments are in progress. These results are believed to be due almost entirely to the methods of set selection recommended in 1906. There is, however, a good deal still to be elucidated. The life history of three undescribed sugarcane parasites has been in great part worked out. One causes a root disease in certain varieties of cane at Samalkota; its study has been carried out chiefly by Mr. Hafiz Khan, who has also investigated a leaf disease at Pusa. The third is prevalent in Behar. Work on sugarcane smut was continued.

Wilt-Diseases.—The results of the work of several years on the wilt disease of pigeon pea were issued as a memoir early in 1910. No opportunity arose for the study of other field crop wilts still awaiting investigation. In November, Mr. McRae visited the Wynaad at the request of the United Planters' Association of Southern India to investigate the pepper-vine wilt. He was accompanied by Mr. R. Anstead, Planting Expert to the Association, in conjunction with whom a scheme of experiments in the treatment of the disease was drawn up. As the cause, and indeed the whole history of this disease are still obscure, little advice of real value to pepper planters can be given as yet.

Ginger rot.—The investigation of this disease, caused by *Pythium gracile*, was continued by Mr. McRae, who visited Rangpur, Eastern Bengal, twice during the season. It is the principal trouble connected with ginger growing in this district and in Gujarat. It is hoped to publish an illustrated account shortly, with suggestions for treatment. Experiments so far appear to indicate that it is possible to check it by careful seed selection and rotation.

Fruit Diseases.—The survey of diseases of temperate fruit trees in India, was continued, chiefly from material

collected in Kashmir in 1908. Wither tip of citrus trees occurred at Pusa and experimental treatment was carried out. Other citrus diseases are under study at Pusa. A papaya disease which has killed a number of trees at Pusa was studied by one of the students and Mr. Mitra, but the work is not yet ready for publication.

Forest Tree Diseases.—As usual a number of these were investigated for the Forest Department and other persons. The chief of interest was *Fomes lucidus*, a probable parasite of several valuable trees including *Shisham* (*Dalbergia sissoo*) and Areca palm. An illustrated note on this was written for the "Indian Forester." The well-known parasite of the Himalayan blue pine, *Trametes Pini*, was discovered for the first time attacking deodar near Simla. Mr. Hafiz has been occupied in an attempt to determine the manner of spread of this fungus from specimens forwarded by the Imperial Forest Botanist.

Other Plant Diseases.—Two diseases caused by species of *Phytophthora* were investigated by the senior students under supervision. The life history of *Phytophthora Colocasiæ* was worked out. The other, which attacks seedling castor, appears to be undescribed previously. The work will be published after some further necessary study. Several cases of disease of important crops caused by the root-rot fungus, *Rhizoctonia*, were studied. Jute, potato, linseed, tomato, brinjal, castor and some pulses are amongst the plants attacked by this fungus, the existence of which in India has only recently been ascertained. An illustrated account of the leaf spot of turmeric, due to a new species of *Taphrina*, has been prepared for publication. Specimens of rice bunt, caused by *Tilletia horrida*, were received from Germany, on rice said to be of Indian origin. As this disease has only been reported from Japan and the Southern States an enquiry is being made as to its possible occurrence in India, especially Burma. The disease of

Para rubber trees due to *Corticium javanicum* was reported from estates in South India. Other rubber tree diseases were received from Burma. The examination of and reporting on these and many other diseases of crops and economic trees formed a large part of the routine work of the section.

Systematic work.—This was prosecuted as time allowed but the progress made was small owing to pressure of other work. As the demands from the Provincial Colleges for correct determination of their parasitic and other fungi are increasing, it is hoped to give more time to the subject than has been possible recently.

Miscellaneous.—Eight show-cases illustrating characteristic fungus diseases of plants were prepared for the Lahore Exhibition and six for the Bengal Department to exhibit at shows. Suggestions were made for regulations for the control of the importation into India of plants or parts of plants likely to introduce dangerous fungus diseases. Mr. Shaw assisted the Imperial Bacteriologist in the laboratory work in connection with Eri silk-worm disease.

Programme of work for 1910-11.—It is proposed to resume the work on soil fungi if time allows.

The work on the wilt diseases of crops, especially of indigo and cowpea and, if opportunity occurs, of cotton, gram and sesamum, will be continued.

The investigation of sugarcane diseases is being continued and the new results will be published.

It is hoped to obtain more information regarding the occurrence of *Rhizoctonia* on the crops mentioned above and to investigate its life history and treatment.

The study of the diseases of papaya, castor, colocasia and rice mentioned above, of tea canker and of heart-rot of blue pine will be continued.

The study of some anthracnoses of pulse crops will be continued.

It is hoped to work through another portion of the collections and to publish the determinations.

The training of students in Mycology will be continued. No student is taking the full course this session.

PUBLICATIONS.

Fomes lucidus (Leys) Fr., a suspected parasite. E. J. Butler. Indian Forester, September 1909.

The Wilt disease of Pigeon Pea and the Parasitism of Neocosmospora vasinfecta Smith. E. J. Butler. Memoirs of the Department of Agriculture in India, Vol. II, No. 9, January 1910.

The Outbreak of Blister-blight on Tea in the Darjeeling District in 1908-09. W. McRae. Agricultural Journal of India, Vol. V, Part 2, April 1910.

REPORT OF THE IMPERIAL AGRICULTURAL BACTERIOLOGIST FOR THE YEAR 1909-10.

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

The principal work of the Section for six months during which I have been in charge has been directed towards a general examination of the bacteria in the soils of Pusa. The scheme of work has resolved itself into :—

(1) Observation of occurrence and activity of bacteria at varying depths in the soil—

(*a*) with regard to varying species;

(*b*) with regard to their relations to soil chemistry.

(*a*) Determination of the species occurring in soils naturally involves a large amount of culture work extending over a long period of time, and has only been undertaken in consideration of the absence of information on this point so far as Indian soils are concerned. It is hoped that further experience gained in this way will enable a distinction to be drawn between those species whose widespread occurrence and activity makes them of importance from an agricultural standpoint, and others whose restricted development renders it unnecessary to study their characters from this point of view.

In addition to cultures made from samples obtained by boring, observations have been carried on periodically as to the bacterial content of soils in the Botanical Section especially those under experimental treatment by "weathering"; it is hoped that some light may be thrown upon the causes underlying the differences resulting from this method of dealing with soils.

The ordinary cultural methods of differentiation have been somewhat restricted by the impossibility of using gelatine owing to the high temperatures at Pusa in the

months of March, April, May and June. It is hoped that it may be found possible in the future to establish a hill station laboratory, where this difficulty may be eliminated during the hot season.

(*b*) The distribution and activity of the nitrifying organisms has been studied closely in samples taken from various depths and localities. The value of the information acquired has been considerably discounted by the contamination of some of the cultures owing to the absence of a suitable room for carrying out inoculations and withdrawing samples. During the dry hot months the air is charged with dust particles carrying innumerable bacteria and the periodical withdrawal of samples from the culture flasks is attended with great risk of infection of the latter, when conducted in the open laboratory. A suitable room, capable of being isolated from the general laboratory and kept free from dust and currents of air, was selected early in February, and arrangements are being made to have it converted for this purpose.

Active nitrification has been observed in borings from the plots attached to the pot culture house down to a depth of 24 inches, the greatest amount taking place in the second six inches. The samples were taken in February, when the dryness of the surface soil would naturally depress the general level of bacterial activity.

It is of interest to observe that salts of magnesia have been found to inhibit nitrification entirely in Pusa soils when the latter are seeded into liquid media. This effect is being further investigated with a view to determining its underlying causes. Samples have been obtained from borings to a depth of nine feet and it has been of interest to discover the relatively enormous numbers of bacteria present in the Pusa soils and their occurrence in the samples taken from the lowest depth, it having been found necessary to use dilutions of one in one hundred thousand in order to obtain a workable number of colonies in plating.

Some work has been done on nitrogen fixation in certain soil samples, but only of a tentative nature, fuller consideration of the subject being postponed until such time as my assistants have acquired more knowledge of bacteriological methods. It is proposed to make exhaustive enquiries into the distribution and characters of nitrogen fixing organisms in Indian soils, as it seems probable that this source of nitrogen is of prime importance and may even afford possibilities of control in actual practice, either by actually supplying such organisms to soils in which they are deficient, or, as the more hopeful means, by adopting methods of agricultural practice which would allow of the fullest development of those already naturally present.

Disease of Eri Silk Worms.—At the request of the Imperial Entomologist, a lengthy enquiry into the causes producing a very high mortality amongst Eri Worms has been undertaken, and is still in progress. The disease, the symptoms of which resemble those appearing in Flacherie of the Mulberry Worm, is associated with the presence of a bacterium, pure cultures of which have been made from the gut of diseased worms; attempts to establish the pathogenicity of this bacterium for Eri Worms, by feeding with leaf sprinkled with water shaken up with the cultures have so far failed to give decisive results. From enquiries made in Assam in the course of a tour undertaken with the object of enquiring into this matter, it appears that the disease, although known to native sericulturists, is considered due to defective feeding and management and not to be of the nature of an epidemic. Further experiments will be carried out with a view to determining the effect of varying food materials and feeding methods. Numerous sections of the intestine of normal and diseased worms were made by Mr. Shaw of the Mycological Section, showing the defective digestion characteristic of the disease and the development of the bacteria in the gut. These illustrate clearly the differences in the digestive processes incident to the disease, but it is not certain whether the increased number of bacteria is a cause or an effect of the

abnormal condition, although it appears probable that they contribute largely to the final result.

In connection with this enquiry, cultures were made from eggs of the Eri moth, which in many cases were found infected with a bacterium, differing however in cultural and morphological characters from that found in the gut of the diseased worms. Eggs of the same brood hatched out successfully forming healthy worms, but the next generation became diseased and died off. Further enquiries will be made as to the transmission of disease by inheritance.

The efficacy of Trope-Ratine, a patent vermin killer specially prepared for use in India, was tested at the instance of the Director. Rats fed on this material appeared to benefit from its nourishing qualities but were otherwise unaffected. One mouse, however, succumbed and was subsequently eaten by the rats without ill effects to the latter. It appears probable that the material had been kept too long since its preparation to retain its original virulence, a period of nearly five months having elapsed since its despatch from England.

I took over charge of the Section on 27th December 1909. As no previous establishment had been formed a Third Assistant was appointed, Mr. C. S. Rama Aiyer, previously acting as an assistant in the Chemical Section here. Subsequently in May, Mr. N. V. Joshi, who then held the post of an assistant under the Agricultural Chemist to the Government of Bombay, at Poona, was appointed as first assistant. The post of a second assistant is still vacant. Owing to the impossibility of obtaining qualified bacteriologists at the small rate of pay provided for this Section, I have been obliged to appoint men without any bacteriological qualifications; this necessarily results in most of my time being spent in training my assistants in the necessary technique, and this will of course retard the progress of the various investigations which, I hope, to carry out. Owing to the very special

nature of bacteriological research, a lengthy course of training and wide experience of the methods in use is necessary before any student can hope to do research work of any value on this subject, and I wish to record my emphatic opinion that in view of the admitted fact that adequate knowledge of the bearing of the biological factor on soil fertility is of prime importance in agricultural practice, it is highly expedient that the work of this Section should be facilitated by the addition of a trained Supernumerary to my staff.

Programme of work for 1910-11.—In addition to the work indicated in the following programme already submitted to the Board in February, certain special subjects for investigation will be taken up as occasion arises and opportunity permits. Of these, the further work necessary on the disease of Eri Silk Worms, and any special work on bacterial diseases of plants, will be leading features.

The Biological aspects of tillage in Indian soils.—This will involve investigations extending over a prolonged period, the basis of which would include a general investigation of the bacterial content of Indian soils.

Concurrently with this general investigation special observations will be made with the intention of determining the biological factors underlying certain problems of agricultural interest such as those connected with the custom of embanking wheat lands. They will also include enquiries into :—

(1) The biological aspects of the availability of plant food in soils.

(2) The biological factors concerned in the decomposition of organic matter in Indian cultivated soils.

(3) Biological aspects of :—

(*a*) Green manuring in India.

(*b*) " Weathering " of soils.

(*c*) Effect of ploughing land when too wet, before sowing.

No. (1) will be carried out in collaboration with the Imperial Agricultural Chemist, No. (2) in collaboration with the Imperial Mycologist, and No. (3) in collaboration with the Imperial Economic Botanist.

REPORT OF THE IMPERIAL COTTON SPECIALIST FOR THE YEAR 1909-10.

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

I held charge of the appointment throughout the year. From the 6th to the 9th July 1909, I visited Bombay to discuss work in cotton with some of the principal merchants there. From the 26th to the 28th July I visited Jalgaon to advise regarding the cotton section of the Exhibition to be held in the following January; from the 13th October to the 11th November I visited the Garo Hills, Dacca and Chittagong in Eastern Bengal at the invitation of the Agricultural Department; from the 12th to the 27th November I visited various parts of Bengal in company with the Economic Botanist with whom I discussed the future line of work to be conducted in his province. From the 28th November to the 7th December I was in the Central Provinces arranging matters with the Deputy Director of the Southern Division, from the 14th to the 16th December I met the Deputy Director of the Northern Division at Harda and settled with him the details of future trials in his division, from the 18th January to the 23rd January I visited the Farms of the Southern Maratha Country with Mr. Clouston, Deputy Director of Agriculture, Southern Division, Central Provinces, and Mr. Main, Deputy Director of Agriculture, Bombay. From the 26th January to the 5th February I attended the Jalgaon Exhibition where I took charge of the Cotton Section and discussed matters of interest with merchants and cultivators of Khandesh and Berar. From the 17th to the 21st March I visited places on the hill tracts of Belgaum and Dharwar to ascertain the progress of experiments with *buri* cotton. From the 1st to the 5th May I visited Cawnpur at the invitation of the Economic Botanist to advise regarding his experiments. From the 21st June till the end of the month I

toured with the Deputy Director of Agriculture, Bombay, and discussed minutely with him the results of the trials achieved so far by him.

The following are the notes and reports drawn up by me and they embody the information and impressions gathered on the more important aspects of the cultivation of cotton in the provinces :—

Eastern Bengal and Assam.—In company with Mr. Hector, I have completed an enquiry on the cultivation of cotton in the Garo Hills and Chittagong Hill tracts.

In a note on the subject of cotton by Mr. Hart based on his visit to the Chittagong Ginning Mill, he states that " one of the important problems to tackle is to find out (1) whether that of the Garo Hills is a better *jat* than those grown in the Chittagong Hill tracts or (2) whether the difference is due simply to soil and climate."

Probably all the hill cottons belong to *Gossypium neglectum*, var. *Assamica* of Watt in his " Wild and Cultivated Cotton Plants of the World." The most perfect form found in the Garo Hills is a very large bolled plant but a smaller bolled variety is also found. This Garo Hill cotton is pronounced to be the finest grown in the Hill tracts of the Provinces and its staple often reaches from $\frac{3}{4}$ to 1 inch in length. It must be remembered, however, that it is not used in commerce as cotton but as a substitute or adulterant in wool manufacture and that any attempt to improve it from the point of view of the cotton merchant would result in a serious diminution of price as it would then at once come into competition with the inferior grades of cotton which are so largely produced in some parts of India more accessible to the markets.

In the Chittagong Hill tracts and probably in all the other tracts also, a small bolled form is common. The cotton is shorter in staple than that of the Garo Hills and the percentage of cotton to seed is lower. We were informed by the American Missionaries at Tura who take special interest in cotton cultivation that they had been

unable to rear tree cottons. Taking into consideration the heavy rainfall of the Hill tracts, it is obvious that any experiment towards the introduction of ordinary commercial cottons, which seldom tolerate a rainfall of more than 40 inches, is doomed to failure. They have, however, promised to undertake trials with *buri* and Cambodia which are known to withstand heavy rainfall but even in the remote event of their success, it is difficult to imagine that they would thrive under the peculiar system of *Jhum*[*] cultivation which, from all accounts, gives the indigenous plant exactly the conditions it requires. Mr. Hutchinson, the Superintendent of the Chittagong Hill Tracts informed me that he made a trial with *buri* cotton. The plants made a good growth and looked so well during the vegetative period that the cultivators were favourably impressed with its possibilities, but finally it refused to form bolls and thus was absolutely unproductive.

There is, of course, no doubt that the Garo Hill cotton is the best and the proprietor of the Ginning Factory at Chittagong classified the cottons according to value as follows :—

(1) *Garo Hill or Chilmari;* (2) *Jala* from Lamding, (3) *Bong* from Chittagong, (4) *Cachari* and *Comilla*. The difference in price to the cultivators between the best and the worst varieties may be only Re.1 per maund, while at the same time, it is understood that this may mean at least Rs. 4 or Rs. 5 to the merchant.

So far as I can gather, and I presume this to be correct, there are scarcely any appreciable differences of climate in these tracts and the rainfall is very heavy. The superiority of the Garo Hill cotton may be due to the great proportion of lime in the soil as calcareous rocks abound. I would suggest that samples of soils be procured from *Jhums*[*] in the Garo Hills and Chittagong Hill Tracts for the determination of this point by the Agricultural Chemist. At the same time, it would be interesting if he could dis-

[*] Temporary fields made in a forest by cutting down jungle and burning it over the land.

cover the reason why *Jhums* require such a long period of rest. The mixture of crops in a *Jhum* seems to be regulated in such a way that each comes to maturity successively. Cotton is the last to do so and when ripening, it covers the ground at about the correct density for the production of a full crop. I learn from Mr. Hutchinson that he has tried the cultivation of Garo Hill cotton on the initiative of Messrs. Ralli Brothers and, in his opinion, the resulting cotton was in no way different from that of the prevailing variety of his district. Mr. K. C. Dewan, Sub-Deputy Collector, says the average acre outturn in Chittagong is 400 to 480 lbs. of seed cotton, while the average of 9 cropping experiments in the Garo Hills gives 500 lbs. of seed cotton and 254 lbs. of clean cotton. This is a percentage of cotton to seed of nearly 51. Taking the Chittagong cotton to have an average of 40 (and it is certainly not more) the acre outturn of clean cotton would only average 176 lbs., leaving an excess in favour of Garo Hill cotton of 78 lbs. per acre. From the bazar rates that I have been able to obtain, it appears that all the seed cotton is paid for at about the same rates while it is obvious that from its superior quality and higher ginning percentage, the buyer should give a higher price for Garo Hill cotton. At present, I understand that the cotton trade is in the hands of native merchants who make advances to the cultivators on the security of the crop and that the method of disposing of the produce finally to Europe is doubtful.

In conclusion, I would recommend (1) that no alteration should be made in the type of cotton grown as the experience of generations has taught it to be the only sort capable of growing under the excessive rainfall and the primitive agriculture of the Hill Tracts; (2) that any selection to be done should be undertaken with the view of increasing the length of the staple, and the percentage of cotton to seed, but not, however, with the idea of modifying the special characteristics of the product; (3) that the Garo Hill cotton should be experimentally introduced

into all the tracts so that it can pass under the judgment of local cultivators and the Chittagong cottons should also be tried on a small scale on the Garo Hills to find out whether the change of locality will affect it as regards size of bolls and quantity and quality of produce. All experiments should be placed under the supervision or control of some officer in the Agricultural Department, as work of this nature, when conducted by men with no training in agriculture, is either neglected or fails through lack of the necessary knowledge.

I have discussed cotton matters freely with Mr. Hector, the Economic Botanist, and he is in possession of my views.

Bengal.—There are three species of *Gossypium* cultivated in Bengal, *viz.*, (1) the late variety, G. *intermedium*, *Todaro* (probably), said to be grown most largely as a mixture with *rahar* and other crops in North Behar; (2) *G. neglectum Todaro*, vars. *Bengalensis* and *Kokatia*, comprised in the "early variety" of the agricultural returns and (3) an early maturing form of *G. hirsutum*, called *Buri*. In addition to these, two American tree cottons—Bourbon and Brazilian or chain-seeded are grown sporadically for their cotton which is used for spinning the sacred thread. Throughout Behar, cotton seems never to be grown as a pure field crop, but only as a mixture with *rahar* (*Cajanus indicus*). Probably little of the produce finds its way to the mills as the bulk is used for stuffing quilts and cushions and for other domestic purposes.

As regards projected experiments with a view of popularising cotton cultivation in Bengal only two species appear to hold out any promise of ultimate success. These are the *intermedium* and *hirsutum*.

According to Mr. N. C. Chaudhary who has devoted considerable attention to the subject of cotton cultivation in Bengal, the advantages of *G. intermedium* accrue from its heavy production and fineness of staple and its drawbacks are comprised in its long period of growth and low percentage of cotton to seed. The crop often occupies the ground until June or July, thereby delaying the cultivators

in the preparation of land for the *bhadoi* crop. The percentage of cotton to seed is said to be only about 20 and the outturn of clean cotton per acre from 50 to 150 lbs. The market rate of the cotton varies from Rs. 12 to Rs. 14 per Imperial maund. Mr. Chaudhary says, however, that owing to the shortage of the crop due to excessive rains, the price is this season at least Rs. 5 higher than usual and that Bhuri cotton has lately been bought by the Calcutta mills @ Rs. 30 per maund.

G. intermedium is said to be represented by two forms, one *Deshila* with small bolls and low percentage, the other *Bhogila*, with larger bolls and higher percentage.

By means of the usual methods of selection, it may be possible to improve these varieties (which are eminently suitable for the soil and climate of Bengal) in the points of which they are at present not quite satisfactory. I shall be obliged if Mr. Woodhouse, the Economic Botanist would undertake a trial on the Bhagalpur College Farm and perhaps Mr. Smith, the Deputy Director of Agriculture, might duplicate the experiment in one or more of his farms. The doubt as to whether these cottons will grow or not need not actually exist, the only questions involved are the possibility of increasing the outturn and percentage. At the same time, if samples are supplied to the Calcutta mills, it would be possible to decide whether or not these cottons are really worth growing. Areas of at least half an acre of each should be grown so that the outturns and percentages could be calculated on a fairly large scale and ample material would also be furnished for purposes of selection.

G. hirsutum, *Buri*, appears to have adapted itself admirably to the natural conditions of the higher lands of Bengal. In Central Provinces, the experience so far gained shows that it withstands a considerably higher rainfall than the local varieties, its outturn and percentage are high and the cotton is valued at the same rate as fine Broach which is accepted as the best of the cottons produced in India. In Bengal, it possesses the valuable charac-

teristic of being a short season variety and being of a low habit of growth it would not compete with a crop such as *rahar*. Its behaviour at the Chaibassa Agricultural Station proves that it thrives even under very unfavourable conditions. I would recommend that careful trials be made with this cotton in the way I have suggested above for *G. intermedium* and in the same localities. It was growing well on the Bhagalpur Farm and I can see no particular objection to its being grown on the Bengal plain. There is another cotton of almost the same characteristics known as Cambodia or Cochin China cotton. This is giving good results both in the Madras and Bombay Presidencies and I have reason to believe that it is still more resistant to heavy rainfall than *Buri*. If early application be made, a supply of seed could probably be obtained from the Deputy Director of Agriculture, Bombay Presidency, Poona.

As regards the two varieties of *G. neglectum*, I consider that they are scarcely worth dealing with, as they are no better than the common low grade cottons which predominate throughout the areas producing the so-called commercial Bengal cottons.

Of the tree cottons, Bourbon may be induced to yield as an annual crop, but it would be advisable not to exploit such an unsatisfactory class of plant.

If the officers of the Bengal Agricultural Department consent to carry out the trials I have suggested, they will not have to undertake a complicated task. They need merely study the possibilities of *G. intermedium* and *G. hirsutum*, the latter preferably in its two forms of *Buri* and *Cambodia*.

Central Provinces.—At the Telinkheri Farm, which I visited in the company of Mr. Clouston, the Deputy Director of Agriculture, the field of selected *Buri* looked extremely well and promised to be highly productive. Mr. Clouston had, with rare judgment, selected a type of plant with short, lower branches and I consider it very fortunate that at such an early period of the cultivation of

this plant he should have had the forethought to pick out what is clearly the best type of plant. I was also pleased to see at Akola that this type had been selected for growth on the seed farms. In Chutia Nagpur, the original Indian home of this variety of cotton, Mr. Woodhouse, the Economic Botanist in Bengal, and myself after examination of the mixed type in the field arrived at the conclusion that this was the type to work on and it was particularly interesting to see at Nagpur and Akola the facility with which this type perpetuates its character of growth. I consider that valuable work is being done in the improvement of cotton in these provinces by the rapid introduction of *Buri*. There is of course the danger of its failure in a season of drought, but in India success can only be attained by incurring a certain amount of risk.

I think that Mr. Evans, the Second Deputy Director of Agriculture, should carefully test the possibilities of this cotton within his charge. From favourable indications afforded by other indigenous varieties already there, I think, his trials will yield him good results. There is, however, at present great variation in the period at which plants ripen their bolls, some plants have completed the process before others have even started, but as all the cotton ripens well within the cold season, this circumstance is perhaps not one of practical importance.

Within the *jari* area, the variety *Malvensis* shows most promise. *Bani* grown at Akola being out of its natural element was actually priced lower than *Malvensis* at Jalgaon. This point is of considerable importance in its way as it goes to prove that *Bani* is the finest cotton in the Central Provinces and Berar only when grown in localities which have been found to be absolutely suitable to it, and care should be taken not to introduce it into tracts where the variety *Malvensis* of *Jari* is indicated as the safer plant to grow. Owing to its requirement for a heavier

rainfall than that prevailing in *Jari* tracts, *Buri* in time may supplant *Bani* or at least it may check the spread of *Jari;* so far as we can see at present, the latter will have no competitor. The only problem in its connection is to ascertain how the outturn of the fine varieties, such as *Malvensis* compares with that of the coarser.

I do not think that any type differing from those we already know will be discovered in this Province. Assuming this to be so, work in cotton should proceed on only a few lines and these may be summarised as follows :—

(1) The introduction of *Buri* to accompany Bani but by no means to oust *Jari.*

(2) The improvement of *Bani* in its percentage and outturn.

(3) The isolation of the different types of *Jari* (which has already been done) and the comparative value of each from the grower's point of view.

I would like to mention here that in my opinion a cotton plot should be at least an acre in extent as the details of outturn are of such vital importance. I find that on small plots too much attention is paid to individual plants and niggling selections are made in trifling differences such as minute variations in the length and quality of lint, etc.

The farmer and trader want to know the outturn and ginning percentage of the crop. The latter will not materially enhance his terms for trifling differences in quality and the former will insist on growing the variety which puts most money in his pocket. The cultivator loses money, however, through his predilection for sending dirty cotton to market. The merchant is often keener on making a good bargain than on paying the farmer higher rates for superior quality.

In addition to what he can secure from Mr. Clouston's long list of selections, I am arranging to supply Mr. Evans

with seeds picked from the best commercial samples obtained from his own division, and I expect he will shortly be in a position to carry through his demonstrations rapidly and soon reach the cultivators. From what I can gather, some of the cottons of his division are already considered good so that his task is simplified to a certain extent.

In conclusion, I wish to record my appreciation of the work being done in cotton by Mr. Clouston and by the projected experiments formulated by Mr. Evans. If they are supported as they deserve, I venture to predict that the Central Provinces will be the first in India to demonstrate that it is possible to obtain a decided improvement in Indian cotton, provided the requisite degree of intelligence and energy are brought to bear on the question and I again repeat that it is futile to work out our problems on flower bed areas.

Berar.—The Province of Berar known in days of yore by the name *Vaidarbha*, has been famous for the cultivation of cotton. It grew some of the best varieties yielding a fine strong fibre. It was the home of the once celebrated *Jari* and *Bani* varieties that afforded a superior sort of material not only to the mill industry in India but also to that in England. At the time of the Civil War between America and England in 1863, when no cotton was received from America, this province supplied the deficiency to a considerable extent.

Area.—Cotton occupies the foremost rank among other agricultural crops, and in comparison to the total cropped area, it is grown much more extensively in this province than in Bombay Presidency. It occupies the second place in India so far as cotton cultivation is concerned, Bombay Presidency being first. Nearly two-thirds of the culturable area is put under cotton, the average area ranging between 28 to 31 lakhs of acres per annum. The average outturn per acre is about 100 pounds clean cotton.

The following six talukas grow the bulk of cotton :—

Akola	740,000	acres.
Amraoti	700,000	,,
Basim	360,000	,,
Buldana	420,000	,,
Ellichpur	350,000	,,
Yeotmal	480,000	,,
	3,050,000	,,

Area under cotton in—

the Central Provinces	1,250,000	acres
Berar	3,000,000	,,
	4,250,000	,,

The valley of the Payanghat has an area under cotton to the extent of about 40 per cent. and this valley, it is said, grows the best cotton.

The area under cotton has of late considerably increased in the districts of Basim and Yeotmal as it is found to be more paying than other crops.

The earliest varieties grown in the Province were *Jari* (Chanda *Jari*) and *Bani*. The former was a cold weather variety with fine silky staple about 1¼ inches long; the latter was sown at the beginning of the rains and had a fine silky staple about an inch long. The best *Bani* was grown in the Wardha District and it was this variety mixed with a considerable proportion of Chanda *Jari* which was known to the trade as "Hinganghat". In Berar *Bani* (possibly with a mixture of *Jari*) was known as "*Amraotis*" or "*Oomaras*."

Now coarse Jari has come into existence which is sown at the beginning of the rains. This is hardier, coarse and prolific in outturn having a staple of about ½ to ¾ inch long.

The two varieties (cold weather *Jari* and *Bani*) yielded a long staple but the outturn of *Bani* was less and was more delicate. Both these varieties had a reputation in the Bombay market until within the last 45 years; but they have been ousted by a variety known as *Kati Bilayati*,

Vilayati, Houri or new *Jari*. The evil seems to have been recognised as early as 1867. Dr. Humes then remarked that :—

"The subject of cotton in Berar is one that requires immediate supervision. It has been left in the hands of ignorant Koonbees, who have no thought for the morrow, but grow whatever pays best at the time. The Khandesh variety is being grown largely to the ousting of the other varieties, to the most certain ruin of the Berar cotton trade. At present they get from Vilayati Khandesh an early crop, also a large one, getting three or four pickings instead of two or three as they get from indigenous cotton. They get R3 or R4 a bale less in price than for the indigenous cotton, but the greater bulk compensates, and much more, for this small loss. But this apparent prosperity will be short-lived, for it is only by mixing this Valayati Khandesh cotton with the indigenous cottons that merchants can get it accepted."

The new *Jari* in recent years has become very popular as its character is sturdy and can stand both excessive rain and partial drought.

Mr. Gaskin, former Director of Agriculture, Central Provinces, says *Jari* is popular for its hardiness and certainty of its heavy yield (1,000 lbs. of seed cotton) giving 330 lbs. lint per acre; the ease with which it is picked up and the fact that it ripens early and so can be placed in the market in October, November.

Bulk for bulk its yield is much larger than that of old *Jari* and *Bani* though the staple is much shorter and less glossy. The old varieties come in the market in January and February whereas the present variety ripens much earlier and enables the cultivator to line his coat with silver in the months of November, December. These circumstances have mostly thrust out the old indigenous varieties of cotton. The change, it is said, came about in this way.

With a view to improve the cultivation in the province, Government introduced the seed known as *Vilayati* or *Houri*, also called *Jari* in some provinces, different from the old Berar *Jari*. The seed was distributed gratis. The trial was so successful and it became so popular that the

old varieties were completely driven out. In connection with the introduction of this variety, Mr. Gaskin observes that by the irony of fate the very cotton which Government endeavoured to eradicate became known as one which they had introduced.

Mr. B. P. Standen, C.I.E., former Director of Agriculture, Central Provinces, states " These are hardy plants which can be cultivated with success in any part of the province when the soil overlies the trap and drains early and the temperature of the cold season is not so low as to kill the plant in December ". According to him, *Jari* (the local *Houri*) has thrust out the old indigenous varieties, *Bani* and old *Jari*, because the former, even in the most unfavourable years, pays better than the latter. The same officer is of opinion that the cultivation of *Bani* on the Ghats south of Berar is due to a spirit of conservatism on the part of the cultivators rather than to any prudential consideration. Not only does *Bani* yield a smaller proportion of lint (25 per cent.) than *Jari*, but it gives also under the most favourable circumstances a small average crop and is more liable to damage from the vicissitudes of the seasons. For these reasons, the old famous varieties of Berar have dwindled and disappeared.

The *Jari* which is cultivated at present is a mixture of the following four varieties mixed to a small extent with Upland Georgian :—

(1) G. N. Rosea. (3) G. N. Vera.
(2) Do. Cutchica. (4) Do. Vera Malvensis, and also *Bani* plants.

Broadly speaking the fibre produced by these varieties increases in value as we go down the list, Rosea producing the shortest staple and priced lowest in the market.

To ascertain the relative value of the outturn of these different types, they were separated out and the seeds obtained were experimented along with Berar *Jari* and *Bani* on the Akola Farm in the year 1907-1908 by Mr. Clouston, the Deputy Director of Agriculture, Central Provinces.

The results are summarised below :—

Name of Variety.	Outturn of seed cotton per acre.	Percentage of lint.	Value of Outturn.
	lbs.		*R a. p.*
Malvensis	240	33	27 0 0
Verum	182	33	17 8 10
Roseum	258	39	24 14 0
Roseum Cutchica	194	38	18 11 3
Berar Jari	255	38	24 9 6
Bani	151	26	16 15 9

From the above statement, it will be seen that Malvensis having good staple has fetched more but the yield and percentage of lint are less than Roseum and Berar *Jari*.

The following was the valuation of these types last year :—

Roseum	₹54 per candy of 560 lbs.		
Cutchica	₹54	do.	do.
Vera	₹54	do.	do.
Malvensis	₹63	do.	do.
Bani	₹64	do.	do.

From the valuation, it is quite clear that Malvensis is a very promising variety and compares very favourably with the *Bani*.

During the current year at the Jalgaon Exhibition all these varieties were exhibited by the Agricultural Department of the Central Provinces. They were subjected to examination and the opinion given by the cotton merchants is as below :—

Buri.—Staple long, fine, good cotton. Value per candy of 784 lbs. ₹340.

Roseum.—Staple coarse, short, free from foreign matter. ₹268 per candy.

Verum.—Softer than Roseum ₹272 per candy.

Berar Jari.—Much cleaner than Khandesh. Will fetch a rupee or two more than ordinary Khandesh. Value ₹270 per candy.

Malvensis.—Not strong, but longer and silkier; much cleaner than Varadi. Value ₹295 per candy.

Bani.—Percentage 26, less silky but longer and stronger than Malvensis. ₹285 per candy.

Note:—Rough cottons are always cleaner than soft cottons.

The basis for valuation was Broach at ₹320 per candy.

Selection of seed.—Seed selection is known by the name of Alkabalka. At one time, it was practised extensively. The mode adopted was to select the best opened bolls at the second picking and stack the cotton. This was separately ginned and the seed so obtained was reserved for sowing for the next season.

Now-a-days on account of the introduction of ginning factories any seed is used for sowing and no effort is made towards selection. At the commencement of the gin factories, the machine ginned seeds were looked upon as unsuitable for cultivation, but this prejudice has unfortunately fast died out and the seed for sowing is purchased from Banias who give such seeds as they have at their own price. It is absolutely necessary to revive the old and useful practice of selecting seed and getting it hand-ginned.

Picking.—This is done usually after *Diwali*, by women and children. Payment is made in kind. 1-20th part of the cotton picked is the labour charges for the first picking; for the subsequent pickings, a higher proportion has to be given. These rates depend upon the cheapness of labour. If the labour is scarce, the rates are higher and *vice versâ*.

This practice is still in vogue in some places, but it has been replaced in recent years by cash payment as the cash payment is found to be cheaper. The usual rate of cash payment is annas three per maund of cotton picked. A

labourer is able to pick from a good field two to three maunds of cotton a day, thus earning from 10 to 12 annas a day. A good crop will give 3 pickings.

Outturn.—The average outturn of *Houri* is about 400 lbs. of seed cotton per acre and its average market price is ₹50 per Khandi of 560 lbs. An acre of land under cotton would thus give about ₹35 to a cultivator from which the cost of cultivation which is usually ₹14 may be deducted; the net profit would therefore be about ₹20.

Bombay.—During the year 1909-10 within a radius of 10 miles from Surat, the seed of a cross grown on the Surat Farm was distributed to the cultivators by the Agricultural Department. The produce of this cross, amounting to about 100 *bhars* 100,000 lbs. (960 lbs. make one *bhar* at Surat) has been purchased through the agency of the Bombay Agricultural Department by a gin-owner of Surat who gave ₹7 more per *bhar* for this cotton than the Surat local cotton. The quantity so purchased will gin out about 30,000 lbs. of seed; in addition to this quantity, the Surat Farm also will produce about 5,000 lbs. seed of this cross, the total quantity of seed would, therefore, come to about 35,000 lbs. It is the intention of the Deputy Director of Agriculture, Bombay Presidency, to distribute this quantity to the cultivators of one village only so that this year one village will grow only the cross cotton which will throw sufficient light with regard to the improvement of cotton.

Cordial acknowledgment is due to Messrs. Tata, Sons and Company, Bombay, for their kindness and promptitude in giving valuations and opinions on cotton samples whenever they were submitted to them.

Programme of work for 1910-11.—The work for the next year will consist of a further enquiry into the cottons of Central Provinces, Central India, Gujarat, Kathiawar and Southern Maratha Country.

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Agricultural Research Institute and College, Pusa

(*Including Report of the Imperial Cotton Specialist*)

1910-11

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Report of the Agricultural Research Institute and College, Pusa,

(Including Report of the Imperial Cotton Specialist.)

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REPORT OF THE DIRECTOR, AGRICULTURAL RESEARCH INSTITUTE AND COLLEGE, PUSA, FOR THE YEAR 1910-11.

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

1. *Charge.*—I held charge of the office of Director, Agricultural Research Institute, and Principal of the Agricultural College, Pusa, throughout the year, in addition to my duties of Imperial Mycologist.

2. *Staff and work of the Institute.*—The Institute is organised in seven scientific sections, Agricultural, Chemical, Botanical, Mycological, Entomological, Second Entomological, and Bacteriological, the detailed reports of which are given in the body of this report. For much of the period under review, the superior staff was below strength. Towards its close, three supernumerary officers were absent on deputation or filling leave vacancies in the provinces; the Imperial Entomologist was on long leave; the Assistant Agriculturist's post was vacant; while I occupied the dual posts of Director and Imperial Mycologist. Thus, there were only eight European officers of the Pusa staff actually at work for the Imperial Department, and of these two (the Imperial Economic Botanist and his Personal Assistant) were engaged in Baluchistan, developing the

fruit industry of that province, in addition to their own duties.

The following summary gives very briefly the organisation of the staff, and the main lines of work of each section during the year.

3. *Agriculture.*—Mr. A. McKerral, Assistant Inspector General of Agriculture, was lent to take charge of the farm up to the 17th November, 1910, when Mr. G. Sherrard, Assistant Agriculturist, took over all except the work in connection with cattle and poultry breeding, which remained under Mr. McKerral until February, 1911. Mr. Sherrard held charge up to the 16th June, 1911, when he was appointed Professor of Agriculture, Bengal Agricultural College, Sabour, and Mr. A. C. Dobbs, Assistant Inspector General of Agriculture, was lent to take charge, pending permanent arrangements. Mr. H. Southern joined the staff as Supernumerary Agriculturist on the 29th November, 1910, but left again on the 13th February, 1911, to officiate for Mr. Sampson, Deputy Director of Agriculture, Southern Circle, Madras, who was about to proceed on leave.

Notwithstanding these frequent changes, and in spite of the fact that since February the farm has been managed by only a single officer, steady progress continues to be recorded. The *rabi* sowings were completed at an earlier date than any previous year, and the harvest was exceptionally good. A yield of 33 maunds of oats per acre was obtained from one field, and a record was established in thrashing, 241 maunds of oats being thrashed in one day with the steam thrasher. The rains set in early in June, 1911, and most of the *kharif* crops were sown before the end of the month and give excellent promise. Against this, the *kharif* of 1910 was marked by extensive floods in Behar, and a large part of the crops on the lower lands was lost owing to a breach in the protective embankment.

The experimental work on the farm suffered from the floods in the monsoon of 1910, one block of the permanent manurial and rotation experiments having been completely

destroyed. The duplicate block on higher land, however, escaped. It is too early to expect results from these experiments. The permanent pasture experiments were abandoned during the year, after full consideration of the results to date. It is evident that the improvement of pasture land will have to be attempted on different lines, and a modified plan of experiment is under consideration. A comprehensive series of manurial experiments with flax was started by the Fibre Expert to the Government of Eastern Bengal and Assam, in collaboration with the Inspector General of Agriculture, but an outbreak of dodder necessitated the destruction by burning of the whole crop. Flax dodder is not indigenous to India, and there is no doubt that every effort should be made to keep it out in future, and to destroy what was introduced in the past. Experiments with jute and paddy were continued, the former according to plans drawn up by the Fibre Expert. As the area under arable cultivation is now more than sufficient to provide fodder and grain for the breeding herd and work cattle, it is hoped to extend experimental work in the near future. A considerable part of the farm is devoted to crops grown for the other sections for observation and experiment.

The farm stock have done well. The Montgomery herd has been increased by natural growth and purchase. Proposals for a dairy were submitted during the year, but sanction has been withheld for the present. There is an undoubted demand for instruction in dairying, and with the large herd of excellent milch cattle now being formed at Pusa, a dairy will ultimately prove an essential part of the equipment of the Institute. The management of the poultry has been in the hands of the Inspector General of Agriculture for the greater part of the year.

I wish to record my appreciation of Mr. Sherrard's work not only on the farm, but in assisting me in the general management of the Estate.

4. *Chemistry.*—Dr. Leather held charge throughout the year. Mr. Annett, on the termination of his acting ap-

pointment as Agricultural Chemist, United Provinces, and on expiry of his privilege leave, resumed charge of his duties as Supernumerary Agricultural Chemist at Pusa on the 11th November, 1910. He has been since appointed to act as Principal of the Agricultural College, Cawnpore, and left Pusa to join this appointment on the 24th June, 1911.

The important investigation on the water requirements of crops in India, to which allusion has been made in previous reports, has advanced a stage, and a second memoir on the subject has been published by Dr. Leather. The principal conclusions arrived at are, that the nature of the soil has no effect on the transpiration ratio, but profoundly influences the rate at which water can move through the soil, and hence the total weight of crop produced. Also, that practically the whole of the water used by a crop is obtained within the root range, some 6 to 7 feet in alluvial soil, the large stores of water below this depth being substantially of no service to the plant.

Drain gauges to test the quantity and composition of the subsoil drainage water from arable land were erected some years ago at Cawnpore and Pusa, and the results of several years' records are now in the press. They yield information of the greatest interest on some of the factors which must always fundamentally influence Indian agriculture, when compared with that of temperate climates. Thus it has been found that the loss of water from bare fallow soil is almost constant year by year in any one place, and is at Pusa nearly double that at Rothamsted in England. At Cawnpore, on the other hand, it is little more than at Rothamsted, and this difference between Pusa and Cawnpore requires to be explained but probably depends on the nature of the soil. The protective influence against evaporation due to the presence of a crop has been approximately determined for different periods of the year. The amount of nitrate present in the drainage water from fallow land is very much greater than at Rothamsted, twice or three times as much, and nitrification occurs with

great vigour after the first heavy rain of the monsoon, but is not active during the dry months.

Dr. Leather has continued his investigation of *usar* land, with special reference to its physical state. He has also, in consultation with the Director of Agriculture, and the Irrigation Department, United Provinces, carried out the first stage of a comprehensive experiment directed to determine once for all whether, as is frequently stated, irrigation leads in certain lands to an increase of alkali.

Mr. Annett is engaged on a general investigation of the Date Palm sugar industry, a very important Indian industry, about which little accurate information is available.

An improved method of refining crude saltpetre was devised by Dr. Leather, and has been described in a Bulletin recently published. More nitrate is obtained than by the ordinary methods in use, the product is of higher quality, less fuel is required, and the process is independent of the weather. Its financial possibilities, however, remain to be demonstrated, and arrangements have been made to test the method on a commercial scale this year.

5. *Botany.*—Mr. Howard resumed charge of this section, on the expiry of privilege leave and deputation in England, on the 29th July, 1910. He was deputed to advise the Kashmir Durbar on hop cultivation from the 1st August to the 27th September, 1910. During his absence Maulvi Abdur Rahman Khan, Second Assistant, held charge of the current duties of the section. Mrs. Howard, who has ably assisted her husband during the past five years, was appointed Personal Assistant for three years from the 1st October, 1910. Mr. E. Holmes Smith, Supernumerary Economic Botanist, was on deputation in the Bombay Presidency throughout the year. He leaves the Department on the expiry of his agreement in October, 1911. Mr. Howard has been placed in charge of a scheme to develop the fruit industry of Baluchistan, in addition to his own duties, for a period of three years from the 1st May, 1911. He will work in Baluchistan for five months, from May to September, each year.

During his absence in England, Mr. Howard carried out some experiments in the production of rust resistant wheats suitable for India, and studied the trade requirements for improved Indian wheat and tobacco. He also enquired into modern methods of hop cultivation and drying and fruit packing, with a view to utilising the information on his return to India.

The possibilities of hop growing in Kashmir are apparent, when it is learnt that with a production per acre of one-fifth of that of Kent, an annual average profit of over £7 per acre has been realised on the Government hop garden, for the last sixteen years. In Mr. Howard's report to the Durbar, the directions are indicated in which improvements are possible, if it is decided to continue the industry on the present lines, and also the steps which are necessary if hop growing in Kashmir is to be placed on modern lines and if Kashmir is to enter the markets of the world as a competitor with California.

Perhaps the most important work on which Pusa is engaged at present is the improvement of Indian wheat. The lines on which this is being carried out have been sufficiently indicated in previous reports of the Botanical Section. The best Pusa wheats produced in 1910 were shown at Mark Lane, and on the Liverpool Corn Exchange, while Mr. Howard was in England, and were acknowledged to be without any superiors on the market at the time. During the past year, the high grain-quality of some of the best of these types has been combined with the high yield of low-quality Indian wheats, as a result of hybridization. The demand, both in India and abroad, for some of the improved wheats produced at Pusa has been far in excess of the supply. It is estimated that over 1,000 acres of the new wheats will be sown in Behar this year. At Raipur and Cawnpore, some of these wheats have proved equally successful, and extended trials have been arranged for at a number of other stations in the wheat-growing tracts of India. Mr. Howard is careful to point out that the full benefit of improved varieties can only be realised if cultiva-

tion is good and moisture is adequate. Disappointment is bound to result, if the influence of these two all-important factors in crop production in India is disregarded.

The improvement of tobacco is being carried on on similar lines to that of wheat. Both in yield and quality of leaf very encouraging results have been obtained.

The botanical study of certain fibres was continued, the isolation of the varieties of *san* (*Crotalaria juncea*) and *patwa* (*Hibiscus cannabinus*), and their improvement by selection and crossing, being the principal work in progress in this direction.

Further work on pollination in important crops of India was carried out, and a Memoir published giving the data for a number of crops.

Towards the end of the year, the lines of work on the improvement of the fruit industry of Baluchistan were developed, and the site of a new Experimental Station for the purpose selected near Quetta.

6. *Mycology.*—I held charge of this section during the year, in addition to the office of Director. Mr. Shaw continued to hold the post of Supernumerary Mycologist.

Much time was given to systematic work, as it was found that progress in Indian economic mycology was greatly hampered by the difficulty in determining the identity of the fungi of the country. All the specimens of one of the larger groups, the Ascomycetes, were worked through and annotated lists were published after the close of the year under review.

The charge of the campaign against palm disease in Godavari and Kistna Districts was taken over by the Madras Mycologist in 1910. It is being continued on the same general lines as before. A full account of the disease, and of the campaign against it carried on since 1907, was written by me and published as a Memoir in September, 1910. The conclusions arrived at are that the operations have been entirely successful in limiting the disease in Godavari to the area previously infected: the work in Kistna was started later, but the progress is encouraging

in this district also. The effect of the work in reducing the severity of the disease within the infected tract was not easy to estimate when the report was written, but with the further records since available it appears that a distinct decrease in the mortality is noticeable at the present time. If the disease can be effectively confined to the existing limits, the outlay incurred will be amply justified, and there is every reason to hope that the continuation of the work will lead to its being gradually stamped out altogether.

The need for a mycologist to work specially on the diseases of the tea plant has become increasingly apparent, and the Indian Tea Association have decided to add an appointment of this nature to their Scientific Department. Meanwhile, Pusa gives such assistance as is possible. Mr. McRae's Bulletin on blister-blight in Darjeeling, published at the beginning of the year, indicates the lines on which the control of this dangerous blight should be attempted. Many planters are experimenting on these lines, but the disease is firmly established and still spreading; unless a cheap and effective method of lessening its ravages can be worked out, there is every reason to fear that the result will be a permanent and considerable reduction of the Darjeeling tea crop. The copper-blight of tea was described by Mr. Shaw, the parasite which causes it not having been previously known to occur in India. A disease of tea seed was investigated by me, and shown to be probably associated with an insect which punctures the seed, and so admits rotting fungi to the tissues of the interior. It is believed that this insect can be fairly easily destroyed.

Other diseases investigated by the section, of which accounts were published during the year, were soft rot of ginger (by Mr. McRae), turmeric leaf spot (by myself), and heart rot of the blue pine (by Mr. Hafiz). Forest diseases, of which the last named is an instance, cause great losses in India; Pusa gives such assistance as it can to the Forest Department, but there is room for a mycologist to work specially at these diseases.

Mr. Shaw is engaged in investigating the root rot of a number of cultivated plants, caused by a species of Rhizoctonia. The parasite appears to be the same in all cases and its complete study, in view of the large range of its victims, is most desirable.

The usual routine work of advising cultivators and the general public interested in agriculture on the diseases of plants and allied matters, which in this section, as in the Entomological, forms a very essential part of the work, was continued. Assistance was also given to Provincial Agricultural Departments in advising on the work of their Mycological assistants, and in providing material for reference collections in their colleges.

7. *Entomology.*—Mr. Lefroy held charge of this section up to the 31st January, 1911, when he proceeded on leave, and Mr. T. Bainbrigge Fletcher, Supernumerary Entomologist, took over charge.

As in previous years, several provinces have freely availed of the assistance offered by Pusa in co-ordinating and checking the work of their Entomological assistants. Of these latter there are now seventeen, some engaged in teaching at the six Provincial Agricultural Colleges, the others in field work. The advisory function of the Entomological Section at Pusa is of great importance in the present position of Economic Entomology in India. The section helps by determining crop pests reported by Provincial assistants, and advises regarding the methods of control likely to be effective in checking them. In several provinces these methods have been demonstrated on a large scale, as in the work against potato moth and surface caterpillars in Bengal, cane grasshopper and potato moth in the United Provinces and several pests in Madras. In Baroda State also, the Entomological Assistant keeps in close touch with Pusa, and has shown much practical energy. In the same connection, mention should be made of the arrangements made directly by the section for demonstrating the life histories and characters of injurious and beneficial insects. A considerable exhibit was

arranged for the Allahabad Exhibition; show cases, coloured plates with brief descriptive leaflets, and coloured lantern slides, were issued for demonstration and distribution to those interested.

Sericulture continues to form an important branch of the work. Eri silk production has been developed as a cottage industry in many parts of India, and received a great stimulus through the display arranged at the Allahabad Exhibition, and smaller exhibits shown at local shows in Bengal. The industry has been taken up by the Agricultural Departments of Bengal and the United Provinces. Difficulty is still experienced in disposing of small parcels of cocoons and thread, the mills being unwilling to buy except in large quantities. Experiments in mulberry silk production have been extended. Crosses were effected between European univoltine and indigenous multivoltine races, with a view to obtaining a robust multivoltine race, yielding silk of better quality than is produced by native forms. Broods of European mulberry silk-worms were successfully reared at Pusa, the resulting thread being well reported on by the trade. Experimental work forms only a part of the activities of the sericultural branch: a great volume of correspondence has arisen in connection with it, and arrangements for the supply of disease-free eggs, castor seed, samples of cloth and machines for spinning, doubling and twisting have required much organising. Twenty students from various parts of India attended the special courses of practical instruction in silk culture during the year.

Lac culture was continued, and a practical training given to students in this subject. A large amount of material was collected, with a view to working out the races of lac insects in collaboration with Mr. Green of Ceylon, a specialist in the group.

Bees of two specially selected Italian strains were imported, and an attempt is being made to acclimatise them at Pusa. Apiculture is still, however, in the experimental stage.

The study of the life histories of injurious insects has progressed, a number of important pests having been reared in the insectary and their habits studied. Mr. Ghosh has prepared a memoir on palm beetles, and Mr. Dutt on some Aculeate Hymenoptera. Other memoirs on life histories are in preparation.

The insect survey of India has been continued as time permits. Large collections have been sent for study by specialists, and to the authors of volumes of the "Fauna of India" series. Mr. Nowrojee has prepared a memoir on some aquatic insects.

The investigation of the damage caused by termites (white-ants), started by Mr. Lefroy in collaboration with Mr. Evans, Deputy Director of Agriculture, Northern Circle, Central Provinces, was continued by Mr. Fletcher. The latter officer was also invited to tour with the Railway Sleeper Commission, to advise on the best methods of reducing the enormous losses caused on Indian railways by these insects, and is carrying out experiments on the preservation of wood from their attacks.

8. *Second Entomological Section.*—This section is engaged in the study of Dipterous insects, and in particular those which suck blood and which may transmit disease. Mr. Howlett, who is in charge of it, only rejoined after absence on sick leave for a year and five months, towards the end of March, 1911. The work of the section was therefore practically in abeyance until the last quarter of the year.

Since his return, Mr. Howlett has had to devote much time to disposing of collections of material accumulated in his absence. The identification of these has progressed with assistance from the Indian and British Museums.

As special work, Mr. Howlett has been engaged in a study of parasites of Tabanidæ ("horse-flies"); the temperature reactions of mosquitoes, temperature apparently being one of the main factors controlling mosquito bite; the relative efficiency of the fish known as "Millions" and other enemies of mosquito-larvæ; and peach flies. In the

latter investigation a method of destroying the male fly, which is simple, cheap and effective, has been discovered, and though it seems improbable that anything short of netting the trees will completely prevent the female reaching them, the destruction of the males should very much reduce the damage done.

While on leave, Mr. Howlett attended as Indian delegate the First International Congress of Entomology at Brussels, and read two papers by Mr. Lefroy and himself. He also carried out, in collaboration with two other gentlemen, a successful series of experiments on the range and rate of flight of house-flies under natural conditions, points of importance in view of their behaviour as carriers of disease. The results were published by the Local Government Board in England.

Since his return, Mr. Howlett has again given invaluable assistance in supervising much of the work of the artist staff, and in advising the other sections in the preparation of illustrations for publication.

In certain respects the work of this section differs widely from that of the other sections at Pusa. It was founded to study Diptera, not only those (comparatively few in number) which are serious crop pests, but also those which convey disease to man and animals. Mr. Howlett's work is, therefore, closely related to the work of the Medical and Veterinary Departments, and it is probable, taking into account the great developments towards a realization of the importance of biting flies as disease carriers, that the activities of the Second Entomological Section will expand in this direction rather than on more purely agricultural lines.

9. *Bacteriology.*—Mr. Hutchinson held charge of this section throughout the year.

Much of his work has been of preliminary nature, confined largely to trial and selection of the bacteriological methods best adapted for dealing with the special conditions of soil and climate in India. The main lines have been aimed at determining under what conditions various

soils will best serve as culture media for those bacteria, naturally present in them, on which the processes of conversion of the organic nitrogen of humus into assimilable nitrates depend.

A special study has been made of the effect of hot weather ploughing on the bacteriological content of the soil, and the possibility of a bacteriological explanation of the undoubted increase in fertility resulting therefrom. It was found that the net result is an extremely rapid formation of ammonia, part of which becomes available to plants and part of which is lost. Depletion of the soil nitrogen is a necessary consequence and the maintenance of fertility must depend on the restoration of this by green manuring or otherwise.

A bacterial disease of tobacco occurring in Rangpur was investigated by Mr. Hutchinson. It was found to be caused by a strain of Bacillus solanacearum, an organism known to cause disease in several cultivated crops, such as potato, brinjal and tomato. The Rangpur strain differs from those described in America and Japan in some of its pathogenic features.

A disease of the Eri silk-worm, which causes havoc in the broods at certain times of the year, was also studied. It was found to be associated with the presence of bacteria in the intestine.

Certain preparations known as Ratin and Trope Ratin, prepared in Copenhagen, have been widely recommended as rat exterminators, and have been suggested for use in India, both with a view to checking plague and to protect crops against the ravages of field rats. Mr. Hutchinson carried out tests of these preparations. Ratin was found to have lost its virulence, but it is suggested that this might be recovered by preparation in India. Trope Ratin was found effective within a limited time after its preparation, but its cost precludes any possibility of its use on a large scale by cultivators. Neither can be recommended for employment at present.

Agricultural Bacteriology in the wider sense, including the bacteriology of industries dependent on agriculture, has made great strides in recent years, and developments in the practical application of this branch of agricultural science in the tropics now appear probable, which were scarcely anticipated when this section was founded at Pusa. Proposals are being made for strengthening the section, which is understaffed.

10. *Training.*—Two different classes of instruction are provided at Pusa. Students are admitted for a post-graduate training in the scientific sections, being ordinarily required to take up a single subject only. Exceptionally, to meet definite requirements of Provincial Departments, which are not in a position to train their own men for such positions as Assistant Director, Farm Manager and the like, post-graduate students have been admitted to a general course, including a period of study in each of the chief sections as well as practical work on the farm. Ordinarily, however, it has been held by the Board of Agriculture that students requiring a practical agricultural training are best provided for by the six Provincial Colleges, and now that these are all in working order, it is not anticipated that there will be much further demand for the post-graduate general course. The second class of instruction given at Pusa consists of short courses of an essentially practical nature in special subjects such as silk and lac culture, cattle and poultry breeding and management, and fruit growing. To these it is hoped to add dairying, for which there is a decided demand which we are not yet in a position to meet, while the course in tillage implements and agricultural machinery was discontinued during the year, as it was not fulfilling any useful purpose. Instruction is imparted in English or in the vernacular, and no educational qualifications whatever are required.

Of the post-graduate students, one continued his course in general agriculture, and one in entomology left after having finished his course during the year. Six students were admitted, two in general agriculture, two in chemistry

and two in entomology. The two students in general agriculture were recalled to their province after completing one year's training, as their services were required by the Provincial Department.

The short courses continue to be popular, students from all parts of India having been admitted. Four took up fruit growing; eight, cattle breeding and management; nine, poultry breeding and management; three, tillage implements and agricultural machinery; twenty, sericulture; and fifteen, lac culture. A certain amount of instruction in bee-keeping was given to some students interested in the subject, but as apiculture at Pusa is still in the experimental stage, regular courses have not yet been established. As far as possible, only those have been admitted to the short courses who propose to take up the subjects taught as a subsidiary means of livelihood to agriculture. In some cases, it was found that non-agriculturists sought admission in order to obtain certificates which would get them employment under Government, especially in Native States. Usually such students were not admitted, or if admitted, certificates were not given to them.

11. *Upkeep of the Estate.*—As a result of the floods, to which the low-lying portions of the farm are subject, and which resulted in a loss of over 100 acres of crops in July, 1910, the Public Works Department was requested to revise the arrangements for draining this part of the Estate, and in particular to repair and strengthen the protective embankments were defective. The flood referred to was probably the highest on record, and gave us a very anxious time, but the bulk of the protective works stood very well, and amply justified the outlay which was incurred on them. The repairs have been deferred pending allotment of funds; fortunately there has been no flood up to date this year.

Two additional blocks of quarters have been constructed departmentally for the use of the staff of the Inspector General of Agriculture, in continuation of those built last year. A new workshop and weigh-bridge for coal were

constructed in connection with the power-house, and plans have been prepared for a coal bunker. The ice plant has been fitted up and is now under trial. It is capable of turning out half a ton of ice in the day. An ice store is being built departmentally. The laboratories consume a good deal of ice which has formerly been obtained from Calcutta, and it is hoped that the new plant will not only prove a convenience but will effect an economy. Much trouble was experienced with the gas supply, owing to the retorts burning out. This culminated in a complete stoppage of gas for some weeks in the hot weather. The Oriental Gas Company of Calcutta kindly spared the services of their Chief Distributing Engineer, Mr. E. P. Reilly, to overhaul the installation. The laying of the retorts was found to be defective, and other minor alterations were carried out under Mr. Reilly's supervision, with the result that no further trouble has been experienced. We are under an obligation to the Company for their courtesy in sending up one of their best engineers to help us.

Provisional estimates for providing a Middle English School for the use of the staff of the Institute and the residents in the neighbourhood were sanctioned, the cost to be borne jointly by the Governments of India and Bengal. The estimates did not provide for residential quarters for the teachers; plans for the school and quarters were prepared with assistance from Mr. Preston, Inspector of Schools, Patna Division, and submitted with revised estimates for consideration by the Bengal Government. Some minor improvements were carried out in the students' hostel.

12. *Library.*—The revised catalogue of the library, corrected up to the end of 1908, was issued. The correction of the proofs and seeing it through the press entailed a great deal of work. The card catalogue was revised, and a register of new additions is now maintained in such a form that further editions of the printed catalogue can be brought out without much trouble. The loan arrangements are working admirably, and I am glad to note that

advantage is being more freely taken of the facilities for borrowing books given to officers of the Provincial Departments. The library is still wanting in many of the more expensive sets of periodicals; the sectional grants for purchase of books usually do not exceed 500 rupees; this is not more than sufficient for current literature, and there is no general grant from which expensive periodicals can be paid for. The new additions amounted to about 1,500 volumes. The library is rapidly becoming overcrowded and proposals for its extension are under consideration. The Director is in general charge of library arrangements and I wish to express my satisfaction with the work of Babu Anukul Chandra Chatterjee, the Librarian.

13. *Publications.*—The Journal, Memoirs and Bulletins were continued. As the Department expands, more work is submitted for publication, the Provincial Departments supplying an increasing volume of contributions. The grant for publications was reduced during the year, and transferred to the budget of the Inspector General of Agriculture. Much of the publication work is now done by the Inspector General, who is Editor-in-Chief, the Pusa staff supervising the illustration work and also acting as an advisory committee. The free distribution list was considerably curtailed during the year, consequent on the reduction of the grant.

14. *General Health of the Station.*—The general health of the station during the year under report was good. Relief was afforded to 7,657 new cases, of which 7,477 were treated in the outdoor department, and 180 admitted as indoor patients. This is an increase of 1,426 cases over last year's total. The increase in attendance was due to the great prevalence of malarial fevers, and cholera, in the surrounding villages. One hundred and forty-six cases amongst European officials and families were attended to, an increase of 47 over last year's total. The daily average number of patients treated was 7·87 indoor and 49·05 outdoor, as against 6·96 and 48·97 respectively during the previous 12 months.

Four deaths occurred in Hospital,—two from malarial cachexia, one from Bright's disease and one from neglected hernia.

Two cases of cholera occurred amongst the families of the Indian staff in August, 1910, with one death. Immediate and successful measures were taken to prevent the disease spreading on the Estate.

One hundred and one surgical operations were performed : of which eight were major and the remainder minor.

The prevailing diseases were malarial fevers, *kala azar*, bowel complaints, rheumatic complaints and skin diseases. Blood diseases were diagnosed microscopically.

Quinine was issued prophylactically on the Estate towards the close of the monsoon.

Fourteen primary and ten re-vaccinations were performed in the early part of the year.

All drains in the building area of the Estate were made pucca during the year. A small cemetery was constructed departmentally. The number of residents within the Estate was over 700 on the date of the recent census.

15. *Accounts.*—The total expenditure incurred during the current year was Rs. 2,99,587, as against Rs. 3,12,427 of the preceding year. The principal items of expenditure are pay of gazetted officers and establishment Rs. 1,87,383, travelling allowance of officers and establishment Rs. 22,315 and farm expenditure, scientific apparatus, books, fuel, stores for electric and gas installation, contingencies, etc., Rs. 89,889. The grant for the " Agricultural Periodicals and Journal " has been transferred from this office budget to that of the Inspector General of Agriculture in India from 1st April, 1910.

The gross receipts during the year by sale of farm produce, milk and other miscellaneous articles, and Mr. Lefroy's book " Indian Insect Life," amounted to Rs. 13,462, as against Rs. 5,573 in the preceding year. Of this amount the sale proceeds of " Indian Insect Life " accounted for Rs. 5,490.

16. *Visitors.*—During the year under report the Hon'ble Mr. E. D. Maclagan, C.S.I., I.C.S., Secretary to the Government of India, Revenue and Agriculture Department, the Hon'ble Mr. F. C. Gates, C.S.I., I.C.S., Financial Commissioner to the Government of Burma, Mr. R. Inouye, Assistant Professor, Agricultural College of Tokio Imperial University, Mons. H. Brenier of the Commerce and Industry Department of French Indo-China, and Dr. Vermoesen, Mycologist Elect to the Belgian Congo, visited the Institute. Dr. Vermoesen worked in the Mycological laboratory for over two months at the end of the year.

REPORT OF THE IMPERIAL AGRICULTURIST FOR THE YEAR 1910-11.

(A. C. Dobbs, B.A.)

Charge of the Pusa Farm during the greater part of the period under report was held by Mr. G. Sherrard, Assistant Agriculturist. The services of the Assistant Inspector General of Agriculture were also placed at the disposal of the Director for farm purposes, and in fact Mr. A. McKerral wrote the Annual Report for 1909-10.

In June 1911 Mr. Sherrard left Pusa to take up the appointment of Professor of Agriculture at the Bengal Agricultural College, Sabour.

Mr. H. Southern was at Pusa as Supernumerary Agriculturist from November 1910 to February 1911, when he left to go to Madras, where he is officiating as a Deputy Director of that Province.

Mr. Ikramuddin held the appointment of First Overseer and Mr. Ziauddin Hyder that of Second Overseer throughout the year.

Mr. Judah Hyam continued in charge of the breeding herd and Mr. Nizamuddin Hyder of the poultry. Mr. L. S. Joseph was appointed Veterinary Assistant in May 1911, and has taken charge of the current duties of the Overseer during Mr. Judah Hyam's absence on privilege leave.

Mahomed Yakub Mukadam of the Lyallpur Farm was appointed as Surveyor in May 1911.

The farm staff is to be congratulated on the thorough and timely preparation of the land for both the *rabi* and monsoon crops which is noted below, and the veterinary staff on the condition, and continued freedom from disease, of the breeding cattle.

Tours.—Mr. Sherrard visited the provincial farms at Dacca and Sabour in December.

Many members of the staff attended the Allahabad Exhibition in connection with the Pusa exhibits.

Training.—Mr. Fatehuddin, B.A., Assistant Director of Agriculture for the Punjab, continued his course in general agriculture during the whole period under report.

Babu B. L. Mukerji, B.Ag., and Babu B. B. Das, B.Ag., stipendiaries of Eastern Bengal and Assam, attended the course of general agriculture from July 1910 till March 1911, when they left to take up their duties at Dacca.

Mr. A. B. Hay-Webb worked on the farm as a visitor from 2nd to 27th March 1911.

The numbers of students attending the short courses have been :—

Cattle-breeding	8
Poultry Management	9
Tillage Implements and Agricultural Machinery .	3*

Character of the Season.—The monsoon of 1910 was early. The rainfall was somewhat small (about 33″), but very well distributed and, in spite of the loss of the crops on large areas of low-lying ground owing to the river rising to a level higher than any previously recorded and owing to the breach of a bund that had previously protected the farm, the crops provided an amount of silage very much greater than the requirements of the cattle for one year. Over 4 inches of rain fell in October, thus ensuring an ample supply of moisture for the greater part of the *rabi* season, and as the sowings were completed at an earlier date than in any previous year since the establishment of the farm, these crops obtained an exceptionally favourable start, which enabled them to give a very good yield in spite of the fact that no further appreciable quantity of rain fell before harvest.

Rain also fell early in June 1911, and, owing again to the land having been thoroughly prepared beforehand, practically all the crops were sown before the end of the month and give excellent promise.

* This course has since been abolished as it has been found to serve no useful purpose.

Cropping.—The greater part of the farm was, as usual, devoted to growing fodder and grain for the working bullocks and the breeding herd. Maize, sorghum, oats, peas, khesari (*Lathyrus*), gram (*Cicer*) and *arhar* (*Cajanus*) were the principal crops grown for these purposes.

The maize provided a large quantity of excellent silage; that from the sorghum was not so good, much of it being decayed, and the right stage at which to cut this crop for siloing under the conditions obtaining here has yet to be ascertained. The oats provided a large amount of excellent feed both of grain and straw. The area of pulses grown was not, however, sufficient to make purchases of this class of food unnecessary.

Much of the *arhar* was spoilt by the floods.

A considerable area was, as usual, sown with Sann hemp for green manure.

Guinea grass, growing on nearly 3 acres within the influence of the bamboo avenues, gave over 300 maunds per acre of green fodder, with only two irrigations in the dry season; lucerne, with constant irrigation, gave over 200 maunds per acre.

Other crops grown on a small scale were flax (which had to be destroyed because of the appearance of dodder) and paddy. Experiments with paddy were inconclusive, the difference between the yields of the plots not exceeding the margin attributable to error.

The projected growth of varieties of wheat in extension of the work done by the Imperial Economic Botanist was abandoned. A large number of crops were grown, on small plots, under observation and for experiments carried on by the scientific officers.

Soybeans, obtained from Nagpur, yielded nearly 7 maunds per acre, which is not sufficient to pay for the cultivation and for the occupation of the land for two seasons.

Permanent Manurial and Rotation Experiments.—These were continued in accordance with the original scheme and the result recorded for future reference.

Permanent Pasture.—The manurial experiments were abandoned this year. There seems to be no doubt whatever that the direction which the experiments on pasture here should take is that of ascertaining the extent to which systematic grazing and extensive surface cultivation, combined possibly with the sowing of quick-growing catch crops, will enable land that cannot be economically used except as pasture to be maintained in a reasonably productive and profitable condition. The upland pasture is now ploughed up every three years and replanted with *doob*, but the *doob* does not look well on close examination even in the first year after planting, and disappears rapidly during the second year. A small part of the ploughed land has been sown with Sann-hemp this year for ploughing in before planting the *doob*.

Thrashing.—A record was established in thrashing the oats this year, 241 maunds being thrashed in one day. The heavy yield of grain, amounting on one field to 33 maunds per acre, no doubt contributed to this result.

Clearing and Levelling.—A large kiln was cleared from the former brick-field and a road across this area laid out and part constructed.

Work-cattle.—The number of cattle in use has been increased by the breaking-in of young cattle, purchased, and supplied from the Montgomery herd. The Montgomery cattle are rather slow, but can pull heavy loads. Foot-and-mouth disease broke out among the working bullocks towards the end of the monsoon of 1910, but was checked and suppressed by prompt measures.

Breeding Herd.—The Montgomery herd has been maintained in excellent condition, and the numbers of cows and heifers increased during the year. Fifty-four cattle were sold and four transferred to the working cattle during the year.

Only three animals died—less than 2 per cent., which is a very small percentage considering that the greater number of the cattle are cows and young calves.

Sheep.—The Gorakhpur sheep have done well, and the cross between them and the Dumbha ram appears to be successful.

Poultry-breeding.—One or two of the varieties of poultry originally imported have proved failures, and others have been substituted for them. Indigenous varieties have been obtained and appear in some cases to be worth keeping. But the work cannot yet be said to be beyond the experimental stage. The distribution of eggs by post and rail has been discontinued, but a considerable number of fowls have been distributed to the provincial farms and sold to private persons.

Programme of work for 1911-12.—1. *Cropping.*—An endeavour will be made to bring the different areas of the farm under systematic rotations suited to each and to the requirements of the cattle. It is proposed to increase the proportion of leguminous crops, and, in view of the excess of fodder provided by the present cropping, to reintroduce revenue-producing crops such as wheat, oil-seeds and possibly tobacco, on a small scale.

2. *Pasture.*—It is proposed to try simple experiments on the effect of surface cultivation and the sowing of leguminous catch crops on pastures.

3. *Laying out.*—The clearing of the former brick-field will be continued when time can be spared. The systematic grading of the fields all over the estate towards the roads or drains, so as to prevent the accumulation of water in patches in the centre of the fields, will be kept particularly in view.

Steps will be taken to prevent erosion and "washing" during heavy rain in a few places where it now takes place.

4. *Breeding-herd.*—The improvement of the milking capacity of the Montgomery herd will continue to be the principal object in view.

5. *Sheep.*—The production of cross-bred sheep with a view to ascertaining the suitability of the Gorakhpur Dumbha cross for mutton production will be continued.

6. *Poultry.*—Further trial will be given to some of the breeds already imported, the requirements of the provincial farms will be kept in view, and indigenous breeds will be further studied. The number of different breeds will probably be considerably reduced.

REPORT OF THE IMPERIAL AGRICULTURAL CHEMIST FOR THE YEAR 1910-11.

(J. Walter Leather, Ph.D., F.I.C.)

Charge of Section and Establishment.—The section was in charge of myself during the entire year.

Mr. H. E. Annett, Supernumerary Agricultural Chemist, acted as Agricultural Chemist, United Provinces, until 10th November 1910. He again went to Cawnpore on 24th June 1911 to act as Principal, Agricultural College.

The changes involved during the year have been as follows :—Babu Subodh Chandra Kar, M.A., the second assistant, died on 19th July 1910. Subodh Babu joined the establishment at Dehra Dun in 1902 as a volunteer assistant and gradually rose to the position of second assistant. He had shown unusual ability and would no doubt have risen to still higher office. His death was a very severe loss. Babu Jatindra Nath Mukerjee, B.A., B.Sc., the third assistant, has been appointed second assistant. Mr. Bhailal Motibhai Amin, B.A., who was promoted third assistant, has, during the year, been appointed on deputation as assistant in the laboratory of the Behar Indigo Planters' Association. Mr. K. S. Vishwanatham, B.A., was selected by the Imperial Bacteriologist as his second assistant. Babu Adhar Krishna Bose was selected by the Scientific Officer, Indian Tea Association, as his assistant. The latter changes, although occasioning loss to the establishment, must be considered in the light of a compliment to the section and fulfil one of its important functions. Other changes have been as follows :—Mr. G. K. Lele, L.Ag., Nagpur, was appointed a junior assistant in August 1910; Mr. D. K. Ambekar, M.A., had to resign his appointment in April on account of family reasons; Mr. R. C. Sohoni left at the end of his probationary period.

Meteorology.—In addition to the ordinary meteorological records, the record of evaporation, which was mentioned in the last annual report, is being maintained. A record of soil temperatures has also been commenced during the year and will yield information as to diurnal and seasonal variations of temperature. Self-recording hygrometer and barometer will also be set up. Most of the information provided by these records will become immediately useful in connection with one or other investigations at the Institute.

Drainage Data.—These are being continued, and the first several years' records together with those of the Cawnpore gauges have been written up for publication. Among the deductions which have been possible are the following:—(*a*) The amount of water draining away annually varies with the rainfall, it being large in wet years; but the amount which evaporates from bare fallow soil is almost constant for any one place. At Cawnpore about 18″ of water thus evaporates per annum, at Pusa about 28″; the corresponding figure at Rothamsted is about 15″. The explanation for the larger amount evaporating at Pusa than at Cawnpore probably lies chiefly in the nature of the soil, but this is a matter which remains to be demonstrated. (*b*) Drainage from cropped land is naturally affected by the extra factor—the crop—and the drainage data have yielded some very interesting information in regard to it. On the one hand a crop transpires large amounts of water; on the other its presence acts as a "shield" to the moisture of the surface soil preventing it, in a measure, from evaporating. Thus the crop introduces into the question two factors, which are mutually opposed to one another, and the amount of drainage occurring from cropped land will be greater or less according to the magnitude of their respective influences. The effect of good crops growing on the Pusa and Cawnpore gauges has been to reduce direct evaporation to two-thirds or one-half of what the soil would have suffered had no crop been present. How much this "protective" effect is, when converted into inches of water, naturally de-

pends on the season of the year. During the dry season the general loss from this cause is much less than during the monsoon; hence the " protection " provided by a " rabi " crop will be generally much less than that of a " rains " crop; the former may be 2″ or 3″, the latter 7″ or 8″ of water. (*c*) The amount of water which runs off the land during heavy rain is known to vary within wide limits, and although the gauges have yielded some information on the subject, it relates to only one soil maintained perfectly level. No very explicit deductions are therefore possible, but the general conclusion has been drawn that perhaps popular ideas have exaggerated its amount.

The Amount of Nitrate in Soils.—This subject is one which has long been considered of great importance, and the drainage water from the gauges, as also some field records, have added much to our knowledge of the subject in so far as India is concerned. The total amount annually formed in fallow land is very much greater—twice or three times—than at Rothamsted. Then another feature has appeared, namely, that nitrification is not active throughout the dry weather, that is in fallow land—not irrigated; absence of moisture in the surface soil during a part of this period might be a controlling factor, but it is not a complete explanation, because the sub-soil is always moist, and here nitrification is similarly restricted to the monsoon. Nor does the variation of temperature offer any better explanation. With the advent of the monsoon, however, nitrates form with astonishing rapidity, the occurrence being most marked immediately after the first heavy rain. This investigation promises to prove of great interest.

The Water Requirements of Crops.—Allusion has been made in previous reports to this subject, and a second memoir, No. 10, Chemical Series, has been published. In continuation of what was published in Memoir No. 8, it has been found that the nature of the soil has no effect on the Transpiration Ratio; at the same time this factor has a great influence on the rate of water movement, and hence indirectly on the weight of crop produced. Field experi-

ments over several years have shown that practically the whole of the water assimilated by a crop is obtained within the root range, some 6 to 7 ft. in alluvial soil, and that although the stores of water present below this depth are very great, they are substantially of no service to the plant. The field experiments were at the same time utilised to check the values of the Transpiration Ratios which had been found by pot-culture methods. The two methods yielded very similar values for this factor.

The investigation into the *availability of plant food* in soils is being continued, but many difficulties have been met with, and its progress is slow.

Usar Land.—Reference was made to this subject in the last report, and the work has been extended. The first investigation had to do with a certain stretch of land in the Mainpuri District, and a very exhaustive series of tests showed that this class of usar land not only contains sodium carbonate, but is also highly impervious to water. The amount of movement of water, whether in the downward direction during wet weather, or towards the surface during the dry period, is thus necessarily only small; consequently also there cannot be any large amount of movement of salts.

Experiments made at Pusa on this soil have shown that by the application of common salt its physical state can be altered and the salts washed out. Rice was grown on some of it last year and is now growing again, but the method is, I fear, not financially feasible. In other experiments also made by pot-culture at Pusa, the physical defect (imperviousness) was separated from the chemical defect (alkali salts) and then plants sown. It was then found that of the two the alkali was the more pernicious.

During the past cold weather the investigation has been continued in another direction in collaboration with the Irrigation Department. One of the features of this alkali land is frequently the occurrence of "alkali spots" in the middle of fields otherwise quite fertile. It has been frequently argued that these result from the presence of

canals and excessive irrigation. The fact that the introduction of a canal is accompanied by a rise of the sub-soil water level has lent support to the argument. The two features are, however, distinct, and it certainly does not *necessarily* follow that they are related. We have some soil, taken from *fertile* land in the immediate neighbourhood of alkali spots under observation; it is maintained fallow with an artificial sub-soil water-supply at 2 ft. from the surface, and the experiment should show whether it will thereby become "alkali."

But the work of the past cold weather dealt with another aspect of this question. It is not only in canal-irrigated areas that "alkali spots" occur in cultivated fields; they are to be found in well-irrigated tracts also. It was decided, in consultation with the Director of Agriculture and the Superintending Engineer, to take samples from a series of such "alkali spots" situated (*a*) within a canal-irrigated tract, and (*b*) within a neighbouring well-irrigated tract, and to compare them by means of such methods as we at present possess. A suitable tract of country was found in the Muttra and Etah Districts. In the Sadabad (Muttra) and western part of Jalesar (Etah) parganas is a tract of country under well-irrigation, and alkali spots occur in many of the fields; thirty such alkali spots were sampled to a depth of 9 ft., excepting in cases where the kankar was too hard to drill through. In the eastern half of pargana Jalesar the irrigation is principally from the Etawah branch, Ganges canal, and in this tract twenty-nine alkali spots were similarly sampled to a depth of 9 ft. In each case a separate sample of every succeeding 6″ was taken, and the whole of the specimens are now under examination. The first tract named is particularly suitable because although it has always depended on well-irrigation, the new Hathras branch of the Ganges canal is under construction, and the tract will hence shortly come under the influence of canal irrigation. All the fifty-nine alkali spots have been registered, mapped to show the approximate area, and the exact position of the boring, from which

the sample was taken in February, registered by means of distance and direction from a stone bench-mark especially put down on the field border. We shall thus not only have the results of the comparative tests of the present year, but it will be possible to form a very exact opinion at a future time, say ten or fifteen years hence, as to whether the introduction of canal irrigation has caused either an increase of the area of these "alkali spots" or any increase in the percentage of "alkali" in the soil. The tests of the soil of experimental plots near Aligarh which were referred to in last year's report showed that the only *really* effective means which had been tried was gypsum, and in that case the cost had been prohibitive. The land which Mr. Keventer has reclaimed was especially interesting. By the application of very large amounts of manure and liberal irrigation, crops have been grown for a number of years on some very bad alkali land. But the samples taken to a depth of 9 ft. showed that the result of the treatment had been to reclaim only the top foot of soil, and that below this layer, the soil is as bad as it was originally. The crops subsist in fact on the liberal manure supply of the top soil and can even then only succeed by the aid of frequent irrigation.

Date Palm.—Immediately after his return from Cawnpore, Mr. H. E. Annett took up, at my suggestion, the general investigation of the Date Palm Sugar industry. Hitherto nothing had been done in relation to the chemistry involved in this industry, and it is obviously desirable that this omission should be rectified. Mr. Annett toured twice in the Jessore District, which is one of the principal centres, and carried out a series of analyses of the juice on the spot and later on of raw sugar at Pusa, besides collecting much valuable information in regard to the methods which are employed. The work will be continued on Mr. Annett's return from Cawnpore.

Saltpetre.—During the year an attempt has been made to work out the practical details of an improved method of refining crude saltpetre which had occurred to me some

years ago as possibly feasible. The chief defects of the present methods are (i) the considerable time required in order to obtain the refined product, (ii) the amount of fuel used is greater than it should be, (iii) a serious loss of nitrate occurs, (iv) much of the refined saltpetre is of low quality, (v) the colour of the refined saltpetre is often brown instead of white, (vi) refining is often interrupted during the rains period.

After working on a laboratory scale, an apparatus was constructed which would deal with a maund of crude saltpetre per charge, and this was worked daily at the Allahabad Exhibition. It was in charge of Babu Jatindra Nath Mukerjee, who has carried out the whole of the experimental work connected with the process. The process is successful in largely eliminating the defects enumerated; nearly nine-tenths of the potassium nitrate in the crude saltpetre is obtained during the day as a white refined saltpetre of over 90 per cent. purity; no water has to be evaporated, and the process is independent of the weather. The other fraction of the potassium nitrate, which is not obtained by this process, remains in the muds and can be extracted by present methods.

The process created a great deal of interest among the refiners who visited the Exhibition, but there is naturally a considerable difference between entertaining an interest and actually replacing the present methods by a somewhat costly machine, and no definite opinion can be formed as to whether the new process will be adopted until it has been tried on a reasonably large scale, so as to form an accurate idea of the actual cost of working it. A proposal is at present under consideration to erect the plant at a refinery in Behar. A Bulletin has also been written on the subject.

Education.—There are two students from the United Provinces and Bengal, respectively, at present undergoing training, and another is to come from Travancore State. There are also two probationary assistants who have recently joined this section, who are in the position of students

Programme of work for 1911-12.—1. The work on the availability of plant food in soils will be continued.

2. In relation to moisture requirements of crops, the current work has to do with the moisture conditions necessary to a green manure crop.

3. The investigation on Usar will be continued on the lines indicated in the body of this report.

4. The chemistry and manufacture of Date Palm Sugar will be investigated by the Supernumerary Agricultural Chemist.

5. Improvements in the refining of saltpetre will continue to be studied.

6. *Education.*—This requires no special comment and will be conducted according to the lines laid down.

Publications.—The following papers have been published :—

Memoir No. 10, "The Water Requirements of Crops in India—II," by Dr. J. Walter Leather, June 1911.

Bulletin No. 24, "The Indian Saltpetre Industry," by Dr. J. Walter Leather and Babu Jatindra Nath Mukerji, August 1911.

"Sugar-cane in India," published in the Agricultural Journal of India, Vol. VI, Part III, by Dr. J. Walter Leather.

"Chapter on Industrial and Agricultural Chemistry" for the Report of Board of Scientific Advice, by Mr. D. Hooper and Dr. J. Walter Leather, 1909-10.

"The Loss of Water from Soils during Dry Weather." Report of the Seventh International Congress of Applied Chemistry, by Dr. J. Walter Leather, 1911.

"The Transpiration of Water by Plants in the Tropics." Report of the Seventh International Congress of Applied Chemistry, by Dr. J. Walter Leather, 1911.

"The Effect of Manure on the Composition of the Grain of Field Crops." Report of the Seventh International Congress of Applied Chemistry, by Dr. J. Walter Leather, 1911.

REPORT OF THE IMPERIAL ECONOMIC BOTANIST FOR THE YEAR 1910-11.

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

Part I.

Teaching, Training and Staff.

Charge.—I held charge of the section during the year under review except for the first 28 days of July when I was on privilege leave and on special duty in England.

Up to the end of July Maulvi Abdur Rahman Khan, Second Assistant, was in charge of the section. During my deputation to the Kashmir State in August and September 1910, he was also in charge of the current work at Pusa. In consequence of the satisfactory manner in which this assistant carried out his duties during five months in my absence in 1910, his services were rewarded by the grant of a special charge allowance for the whole period in question.

Students.—Four short course students attended the section during the year. Three of these worked well, especially the two sent from the Lushai Hills by Major Cole.

Staff.—In addition to the work done by my second assistant, Maulvi Abdur Rahman Khan, during my absence from Pusa in 1910, which has already been referred to, I have pleasure in recording the promising work of this assistant in Economic Botany. The third assistant, Munshi Ijaz Husain, who was in charge of current duties at Pusa on two occasions for short periods, has also improved in his work and made himself useful in connection with the tobacco-curing experiments. The work of the rest of the staff was satisfactory.

Part II.

Special Work in England.

To enable me to complete the work referred to in this section my privilege leave was extended by 17 days to a

period of three months. During this time the work done was the following :—

Wheat.—One of the directions in which the improvement of Indian wheat has been attempted at Pusa has been the increase in rust-resisting power of the kinds at present in cultivation in the plains. This is a subject which has on several previous occasions occupied the attention of the Government of India, but little or no results of practical value have been obtained in the past. It was found at Pusa and at Lyallpur that although the types at present in cultivation differ considerably in rust-resisting power, and that in consequence a considerable improvement in this character is possible by simple isolation methods, nevertheless India does not possess any wheats with the same power of withstanding rust as is shown by many of the wheats of Northern Europe, and especially by American Club. The quality of resistance of the best Indian wheats is of quite a lower order than that possessed by the wheats grown under the more adverse climatic conditions of the North Temperate Zone. This is seen not only when the two classes are grown side by side in India, but also when they are cultivated together in England. One of the directions, therefore, in which improvement might be attempted was, in the light of the work already done at Cambridge on the inheritance of rust resistance in wheat, the production of new kinds by hybridization between Indian wheats and some rust-resistant forms from Northern Europe or America. Attempts to carry this out in practice at Pusa failed on account of the impossibility of getting the rust-resisting parents to flower in time for crossing to be done and for the resulting grain to ripen before the hot weather set in. This difficulty was overcome by sending the Indian parents to Cambridge for spring sowing in 1910 and by carrying out the actual hybridization work in England. Thanks to the facilities given by Professor Biffen at Cambridge, crosses were made by us between various Indian types and American Club and other rust-resistant wheats at Cambridge, and the first generation of the hybrids was

grown at Pusa during the past wheat season. A duplicate set of these seeds was also successfully grown for us at the Cawnpore Experiment Station by Mr. H. Martin Leake, Economic Botanist to the Government of the United Provinces. Now that the difficulty of growing the first generation in India has been overcome, it is expected that among the progeny of these crosses wheats will be isolated of much greater rust-resistance than any of the types now grown in India. The work will be pushed on as rapidly as possible, and it is hoped before very long to have the results on a field scale.

Advantage was taken of my visit to England to consult with Mr. A. E. Humphries, Past President of the Incorporated National Association of British and Irish Millers, on many matters connected with the milling and baking qualities of Indian wheat and to go over in detail the samples sent to England for testing in 1910. I obtained a large amount of valuable technical information on the quality of wheat and also took full opportunity of discussing in detail the lines of future work on the improvement of Indian wheat. I consider Pusa has been exceedingly fortunate in securing for the milling and baking tests not only the invaluable assistance of an authority of the standing of Mr. Humphries in the wheat trade, but also his active interest in the work of improving the crop in India. I consider it will be far better in every way to continue to have the final tests of Indian wheats done in England than to attempt to carry out the work at Pusa under laboratory conditions. Results obtained under such circumstances in India will never carry the same weight as the opinion of the best available expert in the milling and baking trade.

In order to compare the appearance of the new Pusa wheats with those now on the market from various parts of the world, I visited Mark Lane with Mr. Humphries and the Liverpool Corn Exchange with Mr. Broomhall, the proprietor of the *Corn-Trade News and Milling*. It was acknowledged that there were no wheats on the market superior in combined appearance, quality and condition to

the best Pusa wheats. As far as quality only is concerned, Indian wheats are somewhat inferior to Manitobas, but in their greater dryness and in the greater thinness of the skin our best Pusa wheats at least make up for their slight lack of quality. As wheats are sold entirely on the appearance of the samples taken from the ships, it is of the greatest importance to the Indian wheat trade to keep the various grades of Indian wheats separate and not to mix red and white, hard and soft wheats in the same sample. This lowers the price that would otherwise be obtained, while adulteration with earth and other seeds does still greater harm. I saw several good samples of Indian hard white wheat at Mark Lane entirely spoiled by admixture with soft white and red wheat and with dirt and other seeds. A great work remains to be done in teaching the Indian cultivator the great importance of quality, uniformity and appearance in the wheat grown for sale in Europe. In Liverpool, the Pusa wheats were greatly admired and were shown to a meeting of Liverpool millers by Mr. Broomhall, who, in returning the samples to me in London, wrote: "I have just sent you back the samples you left with me. I have shown them to several of our millers who have greatly admired them. The wheat appears equal in value to the best Manitoba." (Letter dated July 8th, 1910.)

While at Liverpool the opportunity was taken of visiting the large new Grain Elevator recently erected by the Liverpool Grain Storage and Transit Company, which embodies all the latest American and Canadian improvements in construction.

Tobacco.—In connection with the work in progress at Pusa on the improvement of Indian tobacco, arrangements were made with one of the Directors of the Imperial Tobacco Company in London to visit two of the best factories in London to see the types of leaf made use of in England. These visits were of the greatest use, and some of the information obtained was applied in the tobacco-curing experiments at Pusa during the past year.

Hops.—In anticipation of my deputation to Kashmir to advise the Durbar on the improvement of the hop industry in that State, three visits were paid to Kent to see the latest forms of hop-drying oasts and the developments which have taken place in hop growing during the last five years. The information obtained was made use of in my subsequent visit to Kashmir.

Fruit packing.—In connection with the proposals for developing the fruit industry of Baluchistan then under the consideration of the Secretary of State, some time was devoted to studying the methods of packing and transporting fresh fruit both in use in England and also employed by the various countries which export fruit to London. Very valuable information was obtained which will be of considerable use in working out the best methods of sending fresh fruit from Baluchistan to India. By a fortunate circumstance I got in touch with one of the Directors of the largest company in Great Britain engaged in the manufacture of fruit packages on the American system, and in consequence have had no difficulty in importing into Baluchistan a large selection of model packages and packing materials for use in the experiments of the present year.

A study of the methods of packing used for transporting fruit from France, the Channel Islands and South Africa to London shows how backward India is in this respect and what great improvements are necessary in this country.

Part III.

The Hop Industry in Kashmir.

In accordance with the orders of the Government of India the months of August and September 1910 were spent on deputation in Kashmir for the purpose of advising the Durbar as to the best means of extending and improving the hop industry. A detailed report on this subject was submitted, which was afterwards printed by the State.

At present hop growing in Kashmir is in a very primitive condition, the average yield of sun-dried hops being less than $2\frac{1}{2}$ cwt. to the acre, or one-fifth the average yield of Kent. In spite of this, however, the net profits are very great, and for the last sixteen years have averaged about 130 per cent. or over £7 an acre.

The natural advantages possessed by Kashmir as a possible competitor in the world's hop production are considerable. Labour is cheap, plentiful, easily trained and easily managed. The soil of considerable areas of the valley is suitable for hops, while irrigation water is abundant, should it be found necessary to supplement the rainfall. Insect and fungoid pests are almost entirely absent, while the cost of transport to India is likely to be much cheaper as soon as the rope railway to Jammu is completed. These advantages, however, are not likely to be utilised to the full unless the Durbar decides to take the necessary steps to place the industry on modern lines.

In the details of cultivation, irrigation, training, picking and drying there is great room for improvement, and it was a great surprise to me to find that even a crop of $2\frac{1}{2}$ cwt. of saleable hops could be produced under present conditions. The cultivation of the crop is exceedingly defective, and a large amount of moisture is lost by the dense growth of grass and weeds and the absence of a surface mulch. This necessitates surface irrigation and the consequent hardening of the land and loss of tilth. Beyond the provision of single poles there are no attempts at training, so that there is insufficient space for the free development of bine and hops. The drying is done on sheets in the sun, and during this process the hops are a good deal broken, and a large amount of lupulin is lost.

In my report an attempt was made not only to present the scientific principles which underlie modern hop production, but also to indicate the improvements which are possible if it is decided to continue the industry on the present lines. In addition the steps were indicated that would be necessary if hop growing in Kashmir is to be placed on

modern lines and if Kashmir is to enter the markets of the world as a competitor with California.

In addition to the work on hops two other matters were dealt with in Kashmir at the request of the Revenue Minister. The first was an investigation into the wine industry, which is carried on by the State near Srinagar, and the second related to a general scheme for the improvement of the agricultural and horticultural industries of the State. In the case of wine industry, I recommended that this should be given up and the past expenditure in this direction regarded as a bad debt. As regards the development of the agricultural industries of the State, I drew up a detailed scheme in which many directions of improvement were indicated, and in which I recommended the amalgamation of the present agricultural and allied efforts of the State into one strong department under a competent European officer with the necessary experience. Time did not permit me to make all the necessary enquiries into a fourth subject on which my advice was asked for by the Revenue Minister and by the Minister for Education. This related to the introduction of Agricultural Education into the State, on which no useful suggestions could be made without first of all going into the present educational system as a whole.

Part IV.

The Development of the Fruit Industry of Baluchistan.

The proposals put forward by this section in 1909 for the development of the fruit industry of Baluchistan were, during the year under review, finally sanctioned by the Secretary of State, and work was commenced at Quetta in May of the present year. This extension of the work of the section has necessarily involved not only some reorganisation of the work at Pusa, but also an extension of the staff. The Pusa work both in training and investigation is now in great measure limited to *rabi* crops, thereby allowing the months May to September to be devoted to

fruit work in Baluchistan. The staff has been strengthened by the addition of a new appointment, that of Personal Assistant, which was given to a candidate who had worked in this section for nearly five years previously as a volunteer.

During the months May and June of the present year the lines of future work on the fruit industry of the Province have been worked out in detail, and a scheme has been put forward which has been accepted by the Local Government.

This falls into three parts. In the first place, a modern fruit experiment station will be started for the purpose both of demonstrating improved methods of producing and transporting fruit and also of affording facilities for further experiments likely to be of practical value to the country. One of the features of the new experiment station will be a nursery in which the best varieties will be propagated in large number for distribution to the zemindars. In the second place, a neglected fruit garden will be taken in hand, and methods of renovation will be commenced this year. Thirdly, steps are being taken to work out the most suitable methods of grading, packing and transporting fruit so as to make the most use of the present facilities for railway transport to India.

The country round Quetta has been explored, and a suitable site for the new experiment station has been selected, and steps have been taken by the local Government to acquire the land. The Honourable Colonel Ramsay, C.I.E., Agent to the Governor General in Baluchistan, who has strongly supported the scheme from the beginning, has placed a large fruit garden at my disposal for the renovation experiment. It is hoped that a beginning will be made with the packing experiments during the present year, and the necessary buildings for the fruit experiment station will be erected by September next.

In the preliminary work involved in the scheme I have been greatly assisted by the Political Officers stationed at Quetta. Mr. H. R. C. Dobbs, I.C.S., C.I.E., Officiating

Revenue and Judicial Commissioner in Baluchistan, has furthered the scheme in every way possible, while I am greatly indebted to Colonel McConaghey, Political Agent, Quetta-Pishin, and to Captain Keyes, Assistant Political Agent, Quetta, for the ready manner in which they have placed their wide knowledge of the country and of the people at my disposal.

Part V.

Investigations.

Wheat.—During the past year the Pusa wheat experiments have been extended in several directions, and results of great value have been obtained.

Seed Distribution.—A beginning was made during the year at several centres in the growth of Pusa wheats for seed distribution purposes. In Behar two planters volunteered to take up the work in 1910, and in both cases the yields obtained were far in excess of those obtained by the people with the local wheats. The seed thus obtained has been widely distributed to other planters, with the result that over 1,000 acres of the new wheats will be sown next October in Behar at a large number of centres. Over 100 maunds of surplus seed grown in the botanical area at Pusa was distributed last April in Behar alone, the demand greatly exceeding the supply. In the Central Provinces some of the early Pusa varieties were grown by Mr. Clouston, Deputy Director of Agriculture, at the Raipur Farm on a fairly large scale. Both in yield and quality these wheats proved superior to the large collection of other Indian wheats grown there. A further supply of other rapidly maturing wheats was accordingly sent to Raipur last April, and the best of these will be grown on a large scale by Mr. Clouston for distribution, mainly in the Chattisgarh Division. Incidentally the wheat experiments at Raipur during the past season indicate that organic matter in the right condition is the limiting factor in wheat production in this tract. This matter is being taken up by

Mr. Clouston, and when the best method of enriching the soil by green manuring has been worked out I feel confident that wheat growing in this and similar tracts will at once be placed on a higher plane. In consequence of the satisfactory results obtained at Raipur, arrangements have been made with Mr. Evans at Hoshangabad for the trial of one of the earliest of Pusa wheats at that station. In the United Provinces the methods of cultivation of wheats which have proved successful at Pusa were tried on a large scale in the botanical area at Cawnpore by Mr. H. Martin Leake, Economic Botanist to the Government of the United Provinces. Both in yield and appearance of the grain the results obtained were very much better than those realised in the district. The Cawnpore results are particularly valuable, as they indicate the possibility of growing large yields of wheat of high quality under canal irrigation. At the Aligarh experiment station Dr. Parr, Deputy Director of Agriculture, United Provinces, obtained very high yields with one of the Pusa selections and has arranged for extended trials of this wheat in his circle during the next year. Arrangements for the trials of Pusa wheats next year have been made at Mirpurkhas in Sind and in the Punjab at Lyallpur and Gurdaspur.

A considerable demand for the new wheats has arisen from Australia in consequence of the satisfactory behaviour of the Indian samples grown there in 1909. In the same year a small sample of Pusa 6 was tried in Hungary with the result that 16 maunds of this variety were asked for by and supplied to the Minister of Agriculture of Austria-Hungary in April last.

One result of the wheat investigations, which is of considerable importance to India and to the future policy of the Agricultural Department, deserves special notice. This is the value of the variety of a crop when it stands alone. It is sometimes thought that in the case of crops improved varieties can be produced of such excellence that when distributed to cultivators greatly improved yields will result, no matter what the methods of cultivation adopted by the

people may be. A little consideration will show that these expectations are bound to result in disappointment as they entirely disregard the fact that two of the limiting factors in crop production in India are the methods of cultivation and moisture conservation adopted. Inadequate preparation for any crop and insufficient moisture cut across the real yielding power of varieties and tend to bring them to the same level. Optimum yields of the varieties and therefore true comparisons in yielding power are only possible if the limiting factors of bad cultivation and poor moisture conservation are removed. The full benefit of improved varieties, and especially those of high quality, can only be realised if cultivation is good and moisture is adequate. It is suggested that in all seed distribution schemes in India due attention should be paid to the prime importance of cultivation and moisture conservation as well as to the value of improved varieties. That it is possible to obtain greatly increased yields using only the means now possessed by the cultivators has been abundantly proved by the results obtained in the botanical area at Pusa during the last three years.

Trade Aspects.—Advantage was taken during the year of several opportunities of bringing the results of the wheat experiments to the notice both of the trade and of those interested in the cultivation of the crop. Everywhere the greatest surprise was expressed that wheats like those shown could be grown in India. In Karachi and Calcutta I ascertained from the leading wheat merchants that no difficulties are likely to be experienced by the growers in disposing (with considerable advantage to themselves) of uniform parcels of wheat of high quality. It is essential, however, that the quantities should be large and that the grades should be maintained from year to year. In Bombay a paper was read on the Pusa wheat experiments in the rooms of the Bombay Natural History Society, at which most of the wheat merchants attended, and at which an exhibit of the new wheats was shown. At the Allahabad Agricultural Conference I opened the discussion on wheat,

and as a result an extended trial of improved wheats and of improved methods of cultivation was arranged on some of the Court of Wards Estates. At the meeting of the Behar Planters' Association in February 1911 an account was given of the improved methods of wheat growing at Pusa which will be tried at a good many centres in Behar next year. Unfortunately, however, the demand for seed which arose after the meeting was far greater than the supply.

Milling and Baking Tests.—The most interesting point with regard to the milling and baking tests of Indian wheats during the past year is concerned with the quality of the new wheats raised at Pusa by hybridizing high yielding Indian wheats of poor quality (Muzaffernagar white and Punjab Type 9) with types of high grain quality but of lower yield. The results obtained show that the problem of combining high yield and high quality has been solved, the new wheats behaving in the mill and bakehouse like the high quality parent. A bulletin summing up the present position of this aspect of the subject and giving the results of 1910 in detail has been published. In response to numerous requests a full account of the actual methods adopted at Pusa in growing the crop has also been included. Translations in Urdu and Hindi of this paper have been prepared during the year by members of the staff.

Influence of the Environment on Quality.—The experiments on this subject which are being conducted in collaboration with Mr. H. Martin Leake, Economic Botanist to the Government of the United Provinces, were greatly extended during the year, and a large number of samples have been forwarded to England for complete milling and baking tests. It is expected that the results will confirm the opinion previously expressed that high quality and high yield both depend on proper cultivation and on proper soil management previous to sowing time.

Tobacco.—A considerable amount of progress has been obtained during the year in the tobacco experiments.

Manuring. – It has been found at Pusa that the success of this crop in Behar depends on the rapidity of growth during October and November, and that this rapid growth is only possible provided a large supply of organic manure in the right condition is added to the soil. It is usual to use indigo *seeth*, oilcake and cattle manure for this purpose, but the application of these substances in sufficient quantity is a costly process. In 1909 it was found that green manuring with *san*, if carried out in good time so as to allow of a thorough incorporation with the soil, was not only as effective as the organic manures usually employed but also far cheaper. During the present year the results were repeated, and trials of the same varieties with *seeth*, *san*, cattle manure and oilcake were made. Both in yield and quality of cured leaf the results with *san* were entirely satisfactory, and accordingly the Pusa results have been brought to the notice of planters interested in tobacco growing in Behar, and extensive trials with *san* are now being made in the district. As in wheat growing it has been found at Pusa that attention to the details of cultivation and moisture conservation are of the greatest importance in tobacco cultivation. About 34 maunds of cured leaf (omitting the lower portions of the stalk usually included in Behar) were obtained to the acre at Pusa last year—a yield greatly in excess of the crops in the neighbourhood.

Curing.—Results of considerable promise have been obtained in the curing experiments which are being conducted in collaboration with the Peninsular Tobacco Company at Monghyr. The varieties used were both American, and also the most promising of the Pusa selections, and the method adopted was a modification of that usually employed by the people. Under the conditions of the experiment the Indian tobacco gave better results than the American, and one of the Pusa selections gave leaf of considerable promise. The experiments are being continued on a large scale.

Breeding.—Both in *Nicotiana tabcum* and in *Nicotiana rustica* considerable progress has been made by the

Personal Assistant in the investigation of the inheritance of characters in this crop which, as was expected, has turned out to be a somewhat complex subject. The object of this work is to discover the mode of inheritance of the various leaf characters in particular so that new and improved varieties can be made by hybridization. Practically nothing is known on this subject, and the scientific breeding of tobacco is still in its infancy.

Fibres.—San (*Crotalaria juncea*, L.).—Several new varieties of this crop have been isolated during the year, and interesting results have been obtained with this crop as a green manure. These are being repeated during the next cold weather at Pusa.

Patwa (*Hibiscus Cannabinus*, L.).—A paper on this crop in India is now about to appear in which the work done during the past four years at Pusa is summed up. Natural cross-fertilization takes place in this crop to a considerable extent, but it has been found possible to eliminate to a great extent the effects of this by removing the hybrids during the seedling and vegetative stages. Possibly these methods can be extended to other Indian crops in which crossing takes place and can be made use of on seed farms.

Pollination.—The importance of a close study of the methods of pollination in the crops of India and the bearing of these matters on the growth of seed for distribution to the cultivators in India were dealt with in a memoir published during the year. This matter was referred to in the previous annual report. The paper in question has attracted a good deal of attention, and the subject has been developed still further during the year. Natural cross-fertilization has been found to occur in *til* (*Sesamum indicum*), *rahar* (*Cajanus indicus*), niger (*Guizotia Abyssinica*) and in Jute (*Corchorus capsularis*). Some progress was made during the year in working out the pollination details in the various oil-seed crops grown in India.

Programme of work for 1911-12.—1. *Training.*—The training of advanced students in this section will be continued.

2. *Plant Breeding and Plant Improvement.*—During 1911-12 the following crops will be studied:—wheat, tobacco, oil-seeds and fibre plants.

(*a*) *Wheat.*—The botanical survey of the wheats of Baluchistan and the agricultural survey of the wheats of Bengal will be completed. The production of improved and rust-resistant varieties by selection and hybridization will be continued. The co-operative experiments on the influence of the environment on the milling and baking qualities of Indian wheats which are being conducted in collaboration with Mr. H. Martin Leake, Economic Botanist to the Government of the United Provinces, will be continued on an extended basis.

(*b*) *Tobacco.*—The production of new varieties by selection and hybridization will be continued as well as the testing and curing of the varieties already isolated. The investigations on the influence of the environment on the stability of the type and quality will be continued.

(*c*) *Oil-seeds.*—The study of the oil-seeds of India will be continued on similar lines to those adopted in the investigations on wheat.

(*d*) *Fibres.*—The isolation and testing of pure races of the fibre plants of India will be continued.

(*e*) *Fruit.*—The fruit experiments at Pusa will be continued on the lines laid down in the First Fruit Report. During the months May to September, the work connected with the development of the fruit industry of Baluchistan will be commenced.

Publications.—The large amount of work that had to be got through during the past year has delayed the publication of results, but it is hoped this will be disposed of during the next year.

A fifth volume of *Die Züchtung der landwirtschaftlichen Kultur-Pflanzen* dealing with the breeding of tropical plants is now being published by Messrs. Paul Parey of Berlin under the editorship of Professor Dr. C. Fruwirth of Vienna. I accepted the invitation to contribute the articles on the following crops :—

Jute (*Corchorus capsularis* and *Corchorus olitorius*), *til* (*Sesamum indicum*), *patwa* (*Hibiscus cannabinus*), rozelle (*Hibiscus Subdariffa*) and *san* (*Crotalaria juncea*), and papers on these have been forwarded to Vienna.

In addition the following papers have been published during the year :—

1. Suggestions for the Development of the Hop Industry of Kashmir. (Printed by the Kashmir State for official use.)
2. The Milling and Baking Qualities of Indian Wheats, No. 3. Some new Pusa Hybrids tested in 1910. Pusa Bulletin 22 (with G. L. C. Howard).
3. The Economic Significance of Natural Cross-fertilization in India. Memoirs of the Department of Agriculture of India (Botanical Series), Vol. III, No. 6 (with G. L. C. Howard and Abdur Rahman Khan).
4. Studies in Indian Fibre Plants, No. 2. On some new varieties of *Hibiscus cannabinus*, L., and *Hibiscus Sabdariffa*, L. Memoirs of the Department of Agriculture in India (Botanical Series), Vol. IV, No. 2 (with G. L. C. Howard).
5. Report on Economic Botany for the year ending June 30th, 1910. Printed in the Report of the Board of Scientific Advice, 1911.

REPORT OF THE IMPERIAL MYCOLOGIST FOR THE YEAR 1910-11.

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

1. *Charge and Establishment.*—I remained in charge of the section throughout the year. Mr. F. J. F. Shaw held the post of Supernumerary Mycologist. Mr. J. F. Dastur was confirmed in his appointment as first assistant. Babu P. C. Kar was appointed to the vacant post of second clerk. All the staff have worked well.

2. *Training.*—Mr. F. Fateh-ud-din, Assistant Director of Agriculture, Punjab, attended for a mycological course once a week up to April 3rd. A forest ranger from the same province received a course of training in fruit diseases up to August 13th. A private student from Bombay abandoned the course early in the year. Amongst visitors Dr. Vermoesen, Mycologist elect to the Belgian Congo, worked in the Laboratory for over two months at the end of the year.

3. *Aid to Provincial Departments.*—Collections of named fungi, chiefly parasitic, have been supplied to the Madras and Mysore mycologists. A considerable number of specimens have been named for nearly all the provinces, the largest number being for Bombay and Eastern Bengal and Assam. Advice regarding the work of Provincial assistants has been given on several occasions.

4. *Plant disease investigations.* (*a*) *Palm diseases.*—A memoir giving a full account of the bud-rot of palmyra, coco and areca palms in Madras was published in September. An organised campaign, having as its object to prevent the spread of the disease and to stamp it out within the affected area in Godavari and Kistna Districts, has been in progress since 1907. The parasite (*Pythium palmivorum*) attacks the crown of the palm only, killing the tree by destroying the growing point. Spores capable of

spreading infection from tree to tree are liberated at an advanced stage of the disease. No other method of checking this infection was found practicable than burning the diseased tops before spores had time to form. This was carried out by gangs of toddy drawers recruited by a staff of subordinate officers of the Revenue Department under the control of a special Deputy Collector. Up to the end of the financial year 1910 about half a million palms had been cut out in Godavari at a cost of some Rs. 50,000. The operations were extended to Kistna in January, 1910. The conclusions given in the memoir are as follows:—"The operations have been entirely successful in limiting the disease in Godavari District to the area previously infected. Now that they have been extended into Kistna, it is fully trusted that they will be equally successful in checking the alarming spread to the south which has been going on for some time in that direction. This alone should fully justify the cost of the operations and their continuation. It is unfortunately impossible to estimate the number of trees saved from attack within the infected area. Still the number of trees saved in those parts where the work has been longest in progress must be many thousands, and apart from preventing any extension in the Godavari District, it is not unlikely that the value of the palms actually saved within the district already exceeds the cost of the operations." Since 1910 the control of the work has passed into the hands of the recently appointed Madras Mycologist, Mr. W. McRae.

(*b*) *Tea diseases.*—A bulletin by Mr. W. McRae, on the outbreak of blister blight of tea in Darjeeling District, was published in July. This contained a more complete account of the disease than the publications on the same subject mentioned in last year's report. It is unfortunately probable that the blight has come to stay in Darjeeling as it does not seem to have appreciably diminished since its first appearance. Many planters are experimenting on the lines suggested by Mr. McRae for its control, but it is evident that effective measures will be most difficult to carry

out. A tea parasite, *Laestadia Theae*, found in Java some 12 years ago but not previously recorded in India, was reported from the Dooars in July. It causes a leaf disease, known as copper-blight, which spreads with great rapidity, but appears to be closely dependent on weather conditions. A note describing its characters was written by Mr. F. J. F. Shaw for the January number of the Agricultural Journal of India. A disease of tea seed known for many years in Assam was investigated by the Imperial Mycologist in collaboration with the officers of the Scientific Department of the Indian Tea Association. It has been shown to be probably associated with the tea seed bug, *Poecilocoris latus*, which punctures the seed and sucks the juice. Through the opening thus made fungi are able to enter, and the subsequent injury to the seed is due to the growth of one or other of several species of rot-producing fungi at the expense of the seed tissues. The Tea Association is issuing a pamphlet pointing out that this insect is probably much more injurious in seed gardens than was previously suspected and recommending measures for its destruction. Several other tea diseases were investigated during the year, in particular the stem canker, the cause of which is still obscure.

(*c*) *Soft rot of ginger.*—Mr. W. McRae published an account of this disease in the Agricultural Journal of India, April, 1911. It is prevalent in Eastern Bengal, Gujarat, and probably elsewhere. In Rangpur the loss in damp soils is 10 to 15 per cent. of the crop; in bad years almost the whole may be lost. The cause appears to be the attack of a fungus (*Pythium gracile*) on the rhizomes and base of the plant. As a result of experiments carried out at Rangpur in 1908-09, Mr. McRae was in a position to recommend effective measures for checking the disease.

(*d*) *Turmeric leaf-spot.*—This is a disease found all over Northern India, but not usually very destructive. It was found by the Imperial Mycologist to be caused by an undescribed species of *Taphrina*, and an account of it was published in the Annales Mycologici in February, 1911.

It is probably responsible for a reduction of the yield which may be much greater than the cultivators themselves suspect, but no treatment can be recommended as yet.

(*e*) *Wilt diseases.*—Experiments carried out at Pusa and independently by the Mycological Assistant of the Bombay Department at Poona, have demonstrated that the fungus which causes *rahar* (pigeon pea) wilt produces virulent spores on the stem of diseased plants. Hence it is advisable to pull out attacked plants early. Mr. Shaw has found that the cause of the death of cotton seedlings at Cawnpore is *Rhizoctonia* and not a *Fusarium* wilt. It is probable, however, that the cotton disease in the Central Provinces, Berars and other parts of India is a true wilt, and it is hoped to investigate this shortly. A gram disease resembling wilt, sent from the neighbourhood of Peshawar, was found to be caused by *Ascochyta Pisi* and not *Fusarium*. A supposed outbreak of indigo wilt which caused a good deal of alarm in September, was shown to be due to leaf-sucking insects.

(*f*) *Sugarcane diseases.*—The field experiments with red rot and *Cephalosporium* disease were abandoned as the plots became infected throughout, and were also attacked by white-ants. Successful inoculations were obtained with a fungus which causes a root disease in Madras and has not previously been described. The Bombay Department is following the recommendations of this section in introducing healthy sets into some districts where red-rot is severe.

(*g*) *Forest tree diseases.*—These continue to occupy a certain amount of time as there is no Mycologist attached to the Forest Department. The chief work of the year was the study by A. Hafiz Khan of the passage from root to root below ground of *Trametes Pini*, the fungus which causes heart rot of the blue pine. He published an account of his investigation in the *Indian Forester*, October, 1910. A serious disease of the *Nahor* (*Mesua ferrea*) has appeared in Sibsagar and Tista Divisions. It is undoubtedly caused by a fungus at the base of the tree, but we have

failed to isolate the species. A leaf disease of Piauhyensis rubber reported from Assam was identified as *Cercospora Cearae*, which has not previously been recorded on this tree. Diseases of sal, Casuarina, babul pods and deodar were also examined for the Forest Department.

(*h*) *Root-rot caused by Rhizoctonia.*—In September of last year a number of crops on the Farm were attacked by a species of *Rhizoctonia.* The crops damaged were principally groundnut, cowpea and jute, at the same time specimens of cotton seedlings from Cawnpore showed similar symptoms of disease. The fungus was isolated from each host and cross inoculations performed with a view to ascertaining whether special races of the fungus are restricted to particular hosts and the extent to which crops are liable to infection in the field. Owing to the subsequent discovery of *Rhizoctonia* on the mulberry and papaw, the scope of the work has since become extended; at present, except in the case of the *Rhizoctonia* on jute, the evidence is against the existence of special physiological races on particular hosts. A fruiting stage of the fungus was discovered on the groundnut and coincides with one which has been previously described as occurring on potatoes in America.

(*i*) *Other plant diseases.*—A disease of wheat which does not appear to resemble any hitherto described, was reported from Dharwar and Hoshangabad. It is hoped to investigate it more fully next season. The anthracnose of chillies caused by *Colletotrichum nigrum* was widespread last year, and we had several enquiries about it. Other anthracnoses examined were those of beans, sida, mango and plantain. An attack of a species of *Phytophthora* on rhea was reported from Dacca. The study of the *Phytophthora* on castor was continued. The downy mildew of *Cucurbitaceae*, *Plasmopara cubensis*, was found at Pusa during the year. This disease, which has been spreading gradually throughout the temperate portions of the world during the past fifteen years from centres in the United States and Japan, was not previously known in India.

The conidial stage of the *Sclerospora* on jowar was found in Bombay and supports the conclusion previously arrived at that the disease is identical with that of bajra due to *Sclerospora graminicola*. The number of parcels of specimens sent in for examination was 97, and, as usual, a large part of the routine work of the section was the identification of these; recommendations for the check of diseases caused by them were given when possible.

5. *Systematic work.*—Much time was given to this branch of the work during the year. It has been pointed out in previous reports that the accumulation of a good classified collection of Indian fungi is as necessary a part of the equipment of the section as the microscopes or other tools of the laboratory. In India, unlike more advanced countries, we have nowhere to turn to to get this work done for us. It is true that we have received generous help from specialists in other countries, but to secure this we have to undertake our share of the work. Within the past few years a large body of the *Phycomycetes*, rusts and smuts of India have been determined. The *Ascomycetes* were taken up last year, and some hundreds of specimens worked through and sent to Berlin, where the determinations will be published in collaboration with Messrs. H. and P. Sydow. Two large groups, the *Basidiomycetes* and *Deuteromycetes*, remain to be worked out, but it will not be possible to undertake their study for some years. Considerable additions to our knowledge of Indian *Phycomycetes* and rusts were also made during the year. Over 600 sheets were added to the herbarium.

6. *Miscellaneous.*—Mr. Shaw assisted the Imperial Bacteriologist in investigations of eri silkworm diseases and tobacco wilt. Eight show-cases of typical fungus diseases of plants were exhibited at the Allahabad Exhibition. A teaching collection of fungi with notes was prepared for the Elphinstone College, Bombay. A report was written on the invasion of *lantana*, a noxious weed of Mysore and Coorg, and measures for its check recommended. The

proposals made in collaboration with the Imperial Entomologist, for the legislative control of plant imports likely to introduce injurious insects and fungi into India, were printed and circulated for the consideration of Local Governments and public bodies interested, and have met with, on the whole, a favourable reception. To carry these proposals into effect will be one of the most important duties of the section in the near future. A note on the organisation of the service for the control of insect pests and fungus diseases was drawn up, also in collaboration with the Imperial Entomologist, for the International Institute of Agriculture, Rome. An outbreak of flax dodder at Pusa was dealt with, the crop being burnt. Recommendations were made to the Scientific Department of the Indian Tea Association of the best means to adopt for disinfecting tea seed intended for export, as this was insisted on in the country for which the seed was intended.

7. *Programme of work for 1911-12.*—1. *Research and Experimental work.*—The work on the wilt diseases of crops will be continued on the lines indicated in the memoir on Pigeon-pea wilt published last year.

The investigation of the fungus diseases of sugarcane will be continued. The chief points of the present enquiry are the spread of red-rot through the soil, the relative immunity of thin canes to this disease, and the study of two undescribed cane diseases.

The study of some fruit diseases commenced last year will be continued, particularly with reference to their control by spraying.

The Supernumerary Mycologist is engaged on an investigation of the root-rot of a number of crops caused by the fungus *Rhizoctonia solani*. This will be continued.

(2) *Teaching.*—This will be continued on the lines indicated in the prospectus. Short courses will also be given to students taking the fruit growing and general courses and to private students, as during the past year.

(3) Advice regarding the fungus diseases of plants will continue to be given to other departments, particularly the

Provincial Departments of Agriculture and the Forest Department, and to the general public. The distribution of named specimens and other material to provincial colleges and other institutions will also be continued.

(4) The collection and identification of Indian parasitic fungi will be continued.

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Report on the Outbreak of Blister Blight on Tea in the Darjeeling District in 1908-09. W. McRae. Bulletin No. 18, Agricultural Research Institute, Pusa, July, 1910.

Soft-rot of Ginger in the Rangpur District, Eastern Bengal. W. McRae. Agricultural Journal of India, Vol. VI, No. 2, April, 1911.

Copper Blight of Tea. F. J. F. Shaw. Agricultural Journal of India, Vol. VI, No. 1, January, 1911.

Root Infection of Trametes Pini. A. Hafiz Khan. Indian Forester, October, 1910.

REPORT OF THE IMPERIAL ENTOMOLOGIST FOR THE YEAR 1910-11.

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

Charge and Establishment.—Mr. Maxwell Lefroy, the Imperial Entomologist, held charge of the section until 30th January, when he proceeded on privilege leave and furlough out of India, the work of the section being then continued by me until the close of the period under review. There have been no changes in the permanent establishment during the year. Mr. C. S. Misra, the First Assistant, who was on privilege leave from the commencement of the year to 9th July 1910, had charge of the field-work on the Pusa Farm and Botanical Area and of the lac work, and has given two courses of instruction to students who attended for the short course in lac culture. Besides this, and apart from the personal instruction given by the Imperial Entomologist, Mr. Misra has had charge of the Laboratory and field training of the students in General Entomology; in this, as in his other work, he has done admirably. Mr. C. C. Ghosh, the Second Assistant, has been in charge of the insectary and has carried out extremely useful work in rearing and observation of insect pests. The Third Assistant, Mr. G. R. Dutt, has been in charge of the economic collections and records and has carried out the issue of coloured plates and lantern slides; in addition to his own heavy routine work, he has found time to study the Aculeate Hymenoptera and has prepared a Memoir on the life history and habits of some of these insects. Mr. D. Nowrojee has been in charge of the general collections of insects and has done very good work in their upkeep and arrangement; this is work which naturally expands automatically every year, but Mr. Nowrojee has been able to do original work as well, and has written a Memoir on aquatic insects which is in the press at the date of this report.

He was away on privilege leave from 16th December 1910 to 6th January 1911. Mr. R. R. Ghose, who held the post of Sericulture Assistant, resigned on 25th October 1910, since when the position has been filled by Mr. M. N. De, who has worked hard and satisfactorily.

Visitors.—The Assistant Professor of Biology in the Punjab Government College, Lahore, and the Lecturer in Entomology at the Cawnpore Agricultural College, both worked in the Laboratory during their vacation periods, the former from December to January and the latter from March to June. The Entomological Assistant to the Baroda State spent a fortnight in Pusa discussing his work and his programme for the ensuing year and in collecting information likely to be of use. The Entomological Assistant, Burma, also spent about three months at Pusa, learning the practical side of Sericulture and obtaining information about crop-pests.

Training.—One student from the United Provinces remained from last year and continued his course in General Entomology until October. During the year, the newly-appointed Lecturer in Entomology at the Lyallpur Agricultural College and the Entomological Assistant in the North-West Frontier Province were received for the full course of training in Advanced Entomology, and will complete their course in December next. It is to be regretted that no students have been sent for the course commencing on 1st June 1911. The short courses in Sericulture were attended by many applicants from all parts of India, and of these thirteen have completed their course during the year; seven other students were received in June 1911, of whom six remain under instruction. The semi-annual short courses in Lac-culture have been taken up by fifteen students, of whom six were Forest Rangers specially deputed for this purpose. A certain amount of instruction in Bee-keeping has also been given to interested applicants, but as Apiculture in the Plains of India is still in an experimental stage, no regular course of instruction can be given before its success is assured.

Provincial Work.—The number of assistants employed in Entomological work in the Provincial Agricultural Departments is now seventeen, of whom six are engaged in teaching in the Agricultural Colleges and eleven in field-work, and of the above numbers two (one in each class) are still under training at Pusa. In view of the enormous areas to be dealt with and the general ignorance of the cultivating classes regarding insect pests and their control, this number appears very inadequate to place the practical side of Economic Entomology in its proper position as a normal part of agricultural practice, but the number of assistants is not being increased in the absence of Provincial Entomologists to direct their work. The fact that Economic Entomology forms part of the regular course in Agriculture at six of the Provincial Colleges must count for something in the spread of a knowledge of crop-pests amongst the agricultural classes. As in previous years, the assistance offered from Pusa in co-ordinating and checking the work of these assistants has been utilised by some provinces, who have referred the more technical work to Pusa, leaving the field-assistants free to undertake practical work and demonstrations.

In Madras, steady progress has been made in investigating the insect-pests of crops and in devising and demonstrating means of control applicable against each, and very good work has been done; this is the more important because the insect-pests of Madras are to a large extent different from those which occur in the plains of Northern India. In the Central Provinces, the experiments against Termites (white-ants) have been continued at Hoshangabad in collaboration with the Deputy Director of Agriculture, Northern Circle, and work against Potato Moth has also been continued. In the United Provinces, good work has been done in demonstration of methods against Cane Grasshopper and Potato Moth. In Bengal, very good work has been done in experiments and demonstration of methods of storing potatoes to keep them from Potato Moth, which is steadily spreading throughout the province. In Eastern

Bengal and Assam, the principal pests dealt with have been the Rice Grasshopper, Semiaquatic Rice Caterpillar and the Behar Hairy Caterpillar. In Baroda State, the Entomological Assistant has done good work in promoting an interest amongst cultivators in such pests as the Hairy Caterpillar, the Bollworm and the Til stem-borer and in inducing the adoption of measures against these and other pests.

Generally speaking, the Entomological work in the Provinces is at present preliminary and is necessarily confined to little more than inspection of the experimental farms, noting the local pests and the destruction caused by them and demonstrating methods to cultivators in the event of any special outbreak. Much more than this cannot be done whilst the Provincial Entomological staff is so limited.

Correspondence.—This is a subject which increases automatically every year as the work of this Department becomes more widely known. In addition to local inquiries as to insects attacking crops received and answered by the Provincial Agricultural Departments, a very large volume of correspondence is received and dealt with at Pusa; this includes a large amount of correspondence received from official sources, but a very large proportion is in reply to questions and requests for information and advice by the general public, and these include queries on almost every conceivable phase of Entomological work—insects damaging crops, gardens, orchards, timber, ornamental trees and shrubs, books and papers, stored cereals and produce of all kinds, insects on domestic animals, silk, lac, bee-keeping, insecticides and sprayers, and the identification of insects—and even on subjects not strictly concerned with insects, such as the destruction of rats. The parcels of injurious insects sent in numbered 166. A total of 2,384 inquiries came in from official and public sources, and the whole of these were dealt with as fully as possible. This is work which occupies a very large and constantly increasing proportion of time, but we consider that this work has a very direct value and that it is our duty to satisfy

every inquirer to the best of our ability. The large increase of clerical work during the year has thrown a great deal of additional work on the Clerk (S. C. Mukerji) and Typist (T. V. V. Subramani), both of whom have worked very satisfactorily and their work deserves special mention.

Research.—Progress has been made with inquiry into the life-histories and habits of injurious insects. Amongst the more important of these have been the Rhinoceros Beetle, the Surface and Painted Grasshoppers, Potato Bug, Lucerne *Hypera*, Small Cabbage Caterpillar, Termites, Rice Weevil, Green Bug, Potato Mealy Bug, Fish Insect and Red Pumpkin Beetle. Experiments have been made on the preservation of wood from attack by Termites (white-ants). Assistance has been afforded to the Imperial Agricultural Bacteriologist in furtherance of his work on the diseases of Eri Silkworms.

Insecticides and Sprayers.—A number of patent insecticides received for trial have been tested and reported on as to their suitability for Indian conditions; as a rule, they are not superior in efficacy to simple mixtures procurable locally, whilst their prices are prohibitive. Information on insecticides for Indian use has been collected in Bulletin No. 23. An increasing number of spraying machines is sold in India every year, and this Department keeps a register of the places where insecticides and spraying machines are obtainable, so that inquirers can be at once referred to the vendor supplying the kind suited to their needs.

Sericulture.—Experiments have been made on the crossing of Italian and French Univoltine Mulberry Silkworms with all the available indigenous multivoltine races, the object being to secure a robust and vigorous multivoltine race yielding a better silk than is produced by the native forms at present cultivated. Up to the present the mongrel races produced by crossing the European univoltine with Nistari and Burmese stock give the best promise as regards yield and quality of silk. Some of the

crosses between multivoltine indigenous races have also produced individuals more vigorous, more productive and less liable to disease than either parent stock. It will, however, require some time to establish a race which can be recommended.

Mulberry Silkworms from European seed were successfully reared at Pusa on bush mulberry in November 1910 and March 1911, the resulting thread having been valued by the trade in Calcutta at prices which compare extremely favourably with that obtainable from any multivoltine race. If it is possible to rear one (or, in many localities, two) broods of European worms on bush mulberry in Bengal and Eastern Bengal—and the Pusa experiments indicate no reason why this should not be done—the fact may have an important bearing on the silk trade.

The cultivation of Eri Silkworms has been continued at Pusa and is at present carried on in almost every district in India. The interest displayed in the cultivation of the Eri worm received a great stimulus through the display of Eri products at the Allahabad Exhibition, where a large building was entirely devoted to sericultural methods and manufactures collected and exhibited by this section. Here every process, from the egg to the finished cloth, was shown actually at work under practical conditions, and all kinds of silk cocoons, threads, cloths, etc., were also exhibited, a gold medal being awarded for these exhibits at the close of the Exhibition. An assistant from Pusa was in charge of the exhibits, and his time was fully occupied in explaining the processes and attending to innumerable inquiries from interested visitors, and particularly in bringing to their notice the advantages of Eri Silk and its cultivation in the provinces in localities where the climatic conditions and other factors are favourable to the adoption and extension of the industry. Batches of visitors—especially of the cultivating classes—were taken round and carefully shown the details of the work. A discussion was also held at the Agricultural Conference at Allahabad regarding the steps to be taken to extend the industry in the

United Provinces. Illustrated pamphlets, in English, Urdu and Hindi, describing the methods of rearing Eri and Mulberry worms, had been prepared at Pusa beforehand, and the real interest evoked by the exhibits could be gauged fairly accurately by the demand for these pamphlets and the large volume of further inquiries which has since come in to Pusa. Besides Allahabad, Mulberry and Eri worms, cocoons, thread, cloth, etc., and spinning and twisting machines in working order were shown at the local Agricultural Exhibitions at Muzafferpur, Bankipur, Malda, Banjetia, Singeswar and Calcutta.

Disease-free Eri and Mulberry silkworms' eggs, cocoons, thread, samples of Eri cloth, castor seed, mulberry cuttings and seed have been distributed to inquirers in all parts of India as far as possible. Trained rearers have also been sent to many places to teach Eri-culture to cultivators and others desirous of trying this product. Arrangements for sale of spinning machines have been continued, and at the request of the Imperial Entomologist, who pointed out what was required, a combined doubling and twisting machine, for doubling and twisting mulberry silk in one operation, was designed and produced by Mr. E. F. Watson and is now on sale. In extension of the work done here Eri silk-work was taken up by the Bengal Agricultural Department at Sabour from 1st April 1911, and it is hoped that the exhibition of this industry, within reach of the silk trade at Bhagalpur, will lead to the extension of the popularity and production of Eri Silk. Eri Silk has also been taken up by the Agricultural Department in the United Provinces, where Mr. Akhtar Mohammad Khan, Deputy Collector, has been deputed to conduct experiments at Shahjahanpur, and at Coimbatore by the Madras Agricultural Department. Successful attempts have been made to twist and dye Tussar Silk, but rearing of this has not been done at Pusa. In March 1911, at the request of the Director of Agriculture, I made a short tour in Eastern Bengal to investigate into the decline of the Mulberry silk trade and advise remedial measures; the result, which has

been reported already, cannot be summarized here. Eri thread of fine count has been produced on a commercial scale by the Chhoi Silk Mill Co. at Bombay, and the use of this fine thread should have an important influence on the development of the industry. There is still some difficulty in the disposal of small parcels of cocoons and thread by rearers on a small scale, the mills being unwilling to buy except in large quantities; a good deal of help in this direction has, however, been afforded by Calcutta firms who have been taking small parcels for shipment of the silk to Europe for experimental purposes.

Lac-culture.—Experimental work in lac-culture was continued, and brood-lac was supplied to applicants in Bengal, Central India, Madras and Bombay. Fifteen students were given a thorough practical training in lac-culture and numerous inquiries on this subject were also dealt with by correspondence. A continuation was made of the collection of material in collaboration with the Forest Department, with a view to the working out of the races of Lac Insects by Mr. E. Ernest Green, Ceylon Government Entomologist, 67 parcels containing 325 lots of specimens from a large number of food-plants having been received during the year. The material, as it accumulates, is sorted out with a view to facilitate the working out of the various races when the collection is completed.

Apiculture.—Two strains of specially selected Italian honey-bees were imported from England in November 1910, with a view to ascertaining their suitability to the conditions prevalent in the plains of India. The experiment has so far proved a success, but it is too early as yet to pronounce definitely on this.

Demonstration.—The most important item under this heading is probably the Allahabad Exhibition. Apart from the exhibits in the Silk House, 15 show-cases of insects injurious to crops and 24 cases showing the food of as many common Indian birds were prepared and exhibited in the Agricultural Court, 19 show-cases of Indian insects

were prepared for the Forestry Court, where this exhibit was awarded a gold medal, and, in the absence of the Second Imperial Entomologist, an exhibit of four show-cases was prepared for the Medical Court by the Supernumerary Entomologist to show the relations between insects and such diseases as Malaria, Enteric Fever, Plague, Myiasis, Cholera, Sandfly Fever, Yellow Fever, etc. I attended the Agricultural Conference held in January at the Allahabad Exhibition, and read a paper discussing practical remedies against two of the most destructive insects of the United Provinces.

Steady progress has been made in the preparation and issue of coloured plates illustrative of insect-pests of crops, and these have been distributed to all Provincial Agricultural Departments, to Museums, Agricultural Societies and numerous Educational Establishments. These plates are available for demonstration and for use in illustration of popular articles in vernacular and other Provincial journals. Show-cases were prepared and sent to the Dasehra Exhibition in Mysore. Coloured lantern slides of subjects selected from the coloured plates of crop-pests have been prepared and a large series of these is now available, besides series on Silk and Lac.

Insect Survey.—Comparatively very little time has been devoted to the general collections, but steady progress has been made, a large number of accessions having been added and arranged. Considerable additions have been made to the Students' Working Collections. Collections have been made up and sent out for identification by specialists and to authors of volumes in preparation for the *Fauna of India* Series: these include *Collembola*, *Orthoptera*, *Tettigidæ*, *Termitidæ*, *Neuroptera*, *Odonata*, *Braconidæ*, and *Ichneumonidæ Hymenoptera Aculeata Dynastidæ*, *Rutelidæ* and *Cetoniadæ*, *Curculionidæ*, *Cleridæ*. *Microlepidoptera*, *Thysanoptera* and *Rhynchota*. Collections have been identified for Provincial Assistants, the Indian Museum, the Bombay Natural History Society's Museum, the Quetta Museum and for many private collectors.

Miscellaneous.—Exhibits illustrating the work of the section were sent to the International Congress of Entomology held at Brussels in August 1910. Entomological inquiries and notes sent in to the Bombay Natural History Society have been dealt with and the Imperial Entomologist lectured to the Society on the eve of his departure from India. Requests from officials and private persons outside of India for information, specimens, etc., have been complied with as far as possible. Live Eri cocoons have been sent to England, France and Morocco.

Programme of work for 1911-12.—The work of the past in advising on insects will be continued, and concurrently the study of the insect-pests of crops will be carried out in the Insectary at Pusa and by the Provincial Assistants. Assistance will be given, when desired, in co-ordinating and directing the Entomological work in the Provinces, and special help will be given in the event of any serious outbreak. The issue of coloured plates and lantern slides will be continued. The experimental work with bees will be continued and extended if possible. Instruction in Eri and Mulberry silk-culture and in the cultivation of Lac will be given to students attending short courses in these subjects. Further collections will be made of lac insects in all stages for the purpose of ascertaining the relationships of the various races. New insecticides and apparatus submitted for trial will be tested with a view to their utility under Indian conditions. Rearing of Eri Silk-worms will be continued and all possible help given to those commencing this industry. Further experimental work will be done on the mongrelisation of the races of the Mulberry Silk-worm, and it is anticipated that the provision of cold-storage at Pusa will much facilitate this. Special attention will be devoted to acquiring a knowledge of Indian Termites (white-ants), the damage they do, and the best methods of preserving crops and constructional material from their ravages.

Publications.—A list of the more important of these is attached, but less and less time is available for work of this

nature as the energies of the staff become more fully occupied in other directions; and this is the more regrettable because a large amount of information relative to the life-histories of many economically important insects has been gathered during the last few years. Amongst the publications now in hand or proposed to be written, and for which a large amount of material is now ready, are practical manuals on lac culture and bee-keeping. Memoirs on life histories of *Orthoptera*, *Hymenoptera*, *Coleoptera*, *Lepidoptera* and *Rhynchota*, a Memoir on Termites, a revision of *Indian Insect Pests*, a revision of *Insects injurious to Indian Agriculture*, and separate manuals on insects injurious to Fruit-trees, Garden-crops and Grains, etc.

Eri Silk as a Cottage Industry. (Pamphlet in English, Urdu and Hindi.) December, 1910.

Mulberry Silk in the United Provinces. (Pamphlet in English, Urdu and Hindi.) December, 1910.

Commercial Possibilities of Eri Silk. C. C. Ghosh (Indian Industrial Conference). December, 1910.

List of Injurious Indian Insects. April, 1911.

List of Insects in Pusa Collection. December, 1910.

Life-histories of Aquatic Insects. D. Nowrojee. (Memoir in the press.)

Food of Birds in India. C. W. Mason. (Memoir in the press.)

Palm Beetles. C. C. Ghosh. (Memoir in the press.)

Life-history of *Croce filipennis*. C. C. Ghosh. (Bombay Journal.) October, 1910.

Hairy Caterpillars in South Arcot. Y. Ramachandra Rao. (Agri. Journal, July, 1910.)

Entomological Demonstration in Baroda. C. U. Patel. (Agri. Journal, October, 1910.)

Two Insect Pests of United Provinces. T. Bainbrigge Fletcher. (Agri. Journal, April, 1911.)

Four Reviews in Agricultural Journal and one in Bombay Natural History Society's Journal.

Insecticides. H. Maxwell-Lefroy. (Bulletin No. 23.) August, 1911.

Eri Silk. H. Maxwell-Lefroy and C. C. Ghosh. (Memoir in the press.)

The Moth-Borer (*Chilo simplex*) by T. Bainbrigge Fletcher. (Pamphlet in English.)

REPORT OF THE SECOND IMPERIAL ENTOMOLOGIST FOR THE YEAR 1910-11.

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

In 1909, after a year and nine months' service, I was absent on sick leave for a year and five months, returning to Pusa on March 22nd last. I have, therefore, now just completed two years of active service, and the present is a convenient opportunity for putting forward one or two conclusions regarding the work of my section.

I was appointed to study Diptera, and in particular those insects which suck blood and which may transmit disease.

Roughly speaking the study of any group of insects usually takes one or two distinct but complementary lines :—

(1) *Taxonomics.*—The study of the structure of dead specimens as a means of obtaining an accurate nomenclature and scheme of classification, thereby facilitating the correlation of results obtained by work in other branches.

(2) *Bionomics.*—The study of the life-history, from egg to adult, and the habits of living insects, their relations with other organisms and the factors which determine their various activities as a means of obtaining knowledge which will enable us to control these activities.

Of these, (1) can be undertaken in any country to which specimens can be sent, and at any place affording sufficient facilities in the way of necessary literature. In this country the Indian Museum is the only institution at present possessing a library with any pretensions to adequacy in respect of Dipterous taxonomics; (2) can be undertaken only on the spot. The elucidation of the life-history and reactions of insects is the only way whereby we can attain to more than an empirical knowledge of how to control them. To follow this line in the case of a group such as Diptera, about which so little is yet known, demands moreover a

somewhat broader scientific outlook than is necessary to the pure systematist.

It would of course be possible to pursue taxonomic studies and occupy ourselves with the description and naming of new species of Diptera, useful work which might well be extended over several years, but this would, in my view, constitute under the circumstances a misdirection of energy, since such work can be better and more easily done elsewhere.

On these and other grounds I have regarded (2) as the direction in which our work should proceed, and I have now a foundation in a knowledge of the main features in the life-history and habits of all groups of blood-sucking insects in India, as also of the few Diptera which are of any considerable direct agricultural importance. I make use advisedly of the phrase "main features," since the present arrangements regarding laboratory accommodation do not admit of insects being kept alive except under conditions so unsuitable as often to make it difficult or impossible to obtain reliable results from observation of individuals in captivity. Our disabilities in this direction are serious, but I am glad to say that steps are now being taken towards the provision of more suitable accommodation.

I returned from England in March, arriving at Bombay on the 10th and at Pusa on the 22nd. No touring has been undertaken since that date. I found that since my departure an amount of material has accumulated which has occupied a good deal of my attention and which will take time to arrange and work out. A portion of our Nemocera has been named by Mr. Brunetti at the Indian Museum, and the identifications of a number of the Tabanidæ sent to the British Museum in 1908 have now been published, which will facilitate work in this group.

I do not here attempt to submit a detailed report of the past four months. In addition to work on the collection and on blood-insects in general, attention has been directed in particular to (1) parasites of Tabanidæ, mainly observations

on an egg-parasite of our common hot weather Tabanus (*T. albimedius*); (2) temperature reactions of Mosquitos; I believe I have found that temperature constitutes at least one of the main factors controlling mosquito-bite; more observations are required, and the work is still in progress; (3) the relative efficiency of "millions" and other enemies of mosquito-larvæ, in progress; (4) Peach-flies; with regard to these last it seems improbable that their attacks can be completely prevented by anything short of netting the trees, but we have now a cheap and simple method (depending on the "chemico-sexual" reactions of the male flies) whereby the damage they do may be very much reduced.

A number of publications are in hand. Four students have been received, though it was impossible to allot them any window-space in which to work.

While absent on sick leave, I attended the First International Congress of Entomology at Brussels, and though unable to enjoy the lavish hospitality which was displayed by the Congress Officials towards all visiting delegates, I was present at all the meetings and read two papers, by Mr. Lefroy and myself. These will be published in the Proceedings of the Congress. From the scientific point of view, the Congress was most successful, the great majority of the papers read being of a high standard of excellence, and I cannot overestimate the value of this opportunity of getting into touch with recent work, and of meeting and exchanging views with Entomologists of other countries.

In connection with a plague of house-flies near Norwich I carried out (in collaboration with Dr. Copeman, F.R.S., Medical Inspector to the Local Government Board, and Mr. Merriman) what I believe to be the first successful series of experiments on the range and rate of flight of these insects under natural conditions, a point of considerable importance with regard to disease-transmission. The results are published in "New Series No. 53 of the Local Government Board Reports on Public Health and Medical Subjects."

Prior to sailing for India I spent five weeks in Cambridge, working in Professor Nuttall's laboratory on the

respiratory mechanism of Ticks and the influence of temperature on rat-fleas; I may remark that the temperature which was fatal to adult fleas was found to be unexpectedly low. I also prepared several illustrations for Professor Nuttall, made an experimental study of the effects of various degrees of magnification and reduction in reproducing drawings and wrote two articles [on (1) Mosquitos and Temperature, (2) Methods of preserving Insects] which were published in "Parasitology."

Programme of work for 1911-12.—Work on blood-sucking insects, ticks, and other similar parasites directly or indirectly injurious to man will be continued, and attention will also be given to Dipterous pests of crops and fruit. Instruction will be given to agricultural students in these subjects.

A large amount of time will have to be given to working through and arranging the material which has accumulated during my absence, sent in by Medical and Veterinary Officers.

Special investigations proposed are :—

(1) Life-history and habits of Simulium (hill cattle-fly), the dung-infesting Cattle-flies, Sand-flies, and such house-flies as are likely to be found acting as carriers of intestinal diseases.

(2) Bionomics of Mosquitos, with special reference to the influence of temperature.

(3) Influence of external conditions on the life-history of Fleas.

(4) Reaction of Diptera to chemical stimuli.

REPORT OF THE IMPERIAL BACTERIOLOGIST FOR THE YEAR 1910-11.

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

The work of the Bacteriological Section during the past year, the first during which it has been in operation, has necessarily been largely confined to trial and selection of the methods best adapted for dealing with the special conditions of soil and climate obtaining in India. The biological analysis of a soil not only involves a determination of the number and kinds of bacteria contained in it and their relation to the production of plant food, but must also include investigations having for their aim the discovery of how such bacterial functions as make for fertility may be encouraged and used to the best advantage in the ordinary operations of agricultural practice. Hence the main lines of work of this section have been aimed at determining under what conditions various soils will best serve as culture media for those bacteria, naturally present in them, upon which the processes of conversion of the organic nitrogen of humus into assimilable nitrates depend.

Much preliminary work has been done in testing methods already in use, and modifying them in accordance with the requirements of local conditions.

Special attention has been paid to methods of plating soils in such a way as to obtain information as to the number, kinds, and functions of the bacteria in them; this has involved a study of media suitable for the purpose, and of methods of inoculation, and this study is still in progress, as it appears probable that each soil requires variation in the composition of the medium in which it is to be plated, in accordance with its chemical and physical character, and with special regard to its previous agricultural history. In soil plates made for the purpose of counting the numbers of bacteria present per unit volume or unit weight,

special attention must be paid to the variations in soil climate previous to the time of sampling, as otherwise erroneous conclusions may be drawn as to the number of bacteria normally present. For instance, a rainfall of one-tenth of an inch in December has been found to raise the number of bacteria to 100 millions per gram in the course of 36 hours, whereas the same soil contained only 5 millions per gram two weeks later. Similarly the rate of decomposition and nitrification of organic matter in Indian soils appears to be very different from that which has been observed in Europe, and is no doubt to be correlated with the special conditions of soil and climate of this country. These cases have been referred to as illustrations of the necessity for proceeding with great caution in working out special problems by the application of generally accepted methods.

A complete series of experiments has been carried out to determine the best means of sterilizing soils, as the majority of experiments on soil bacteriology depend upon work with sterile soil as a medium. Great difficulty has been experienced in obtaining completely sterile soil; intermittent steaming in many cases has failed to ensure sterility, possibly owing to the rapid formation and germination of spores by some of the numerous spore formers present, and the use of the autoclave for pots of soil, of which only one can be inserted at a time, makes an experiment involving the use of some 50 pots almost impracticable, owing to the differences in time involved. A sterilizing plant for dealing with a large number of pots simultaneously is very much needed.

Samples of Pusa soils have been analysed bacteriologically, pure cultures of the bacteria found have been made, and their physiological functions examined. Special attention has been paid to their relative ammonifying power, and the knowledge thus obtained is now being utilized in dealing with special problems.

A special study has been made of the effect of hot weather ploughing upon the bacterial content of the soil and

its possible relation to the undoubted increase in fertility resulting therefrom. It has been found that this operation increases the rate of ammonification of the soil humus, probably by the selective action of combined desiccation and abnormal temperature; similar results can be obtained by heating the soil to 60° C., the soil plates shewing a survival of the more active ammonifiers such as B. Mycoides and B. Subtilis, whilst the highly aerated condition of the soil inhibits the activity of surviving anærobic spore formers. The net result is an extremely rapid formation of ammonia, part of which is retained by the soil and nitrified or taken up directly by plants, and part is lost by diffusion; in this way rapid depletion of the soil nitrogen must take place, and subsequent fertility will depend upon the judicious use of green manures; the economic value of the method depends upon the power which it places in the hands of the agriculturist of rapidly converting green manure or other organic nitrogen into plant food, although this may be counterbalanced to some extent by loss of nitrogen as ammonia.

Study of Pusa soil taken from depths down to nine feet shows large numbers of bacteria even at this low level; nitrification has been found actively proceeding in the third foot from the surface, the greatest amount of this taking place in the second six inches. Owing to the open texture of this soil it is improbable that denitrification occurs to any appreciable extent, but the rapid rate of ammonification and the vigorous growth of soil bacteria no doubt interfere with the production of nitrates.

A method of quantitative estimation of the changes in soil due to bacterial action, by periodical analysis of the soil gases, has given much information as to the conditions favourable for nitrification in soils; it is hoped that this method will be invaluable in the future for dealing with such problems as arise out of soil irrigation and drainage, and the use of green manures.

In connection with the experiments upon soil sterilization as a laboratory method, investigations have been car-

ried out to determine the effect of various methods of partial or complete sterilization upon fertility; these investigations are still in progress and have yielded some results of great interest, such as the fact that the addition of Toluene to a soil already sterilized by heat increases its suitability as a medium for the growth of ammonifying bacteria and consequently its fertility; this renders it unnecessary to assume that such action is due to the suppression of phagocytes, although there is of course no reason why such removal should not contribute to the general effect in soils partially sterilized by addition of Toluene.

So far but little work has been done upon any but local soils, as these have afforded ample opportunity for research, but samples of *Usar* soil have been examined in connection with the use of gypsum, cattle manure, and straw as means of modifying their infertile condition. Dr. Leather kindly supplied samples of these soils, and also some black cotton, Shillong, Bangalore, and Akola soils, which have been used for purposes of comparison with Pusa soils.

A circular letter was addressed to Directors of Agriculture and Principals of Agricultural Colleges in the Provinces with a view to eliciting their opinions as to the scope for bacteriological work on soils, and the existence of special problems of local interest suitable for investigation by this section. The replies were of great interest as shewing the very general realization of the value of such work, and many useful suggestions as to lines of enquiry were received. The opinion was expressed in several quarters that the training of assistants as soil bacteriologists who would be capable of dealing with local problems in the Provinces, should be an important item in the work of this section at Pusa. This is a point of view with which I am in complete agreement and I wish to express my opinion that the work done during the past year has shown the necessity for training in the use of the special laboratory methods which are necessary in India, and that such assistants as may be selected for work on soil bacteriology in the provinces

should undergo a preliminary training at Pusa. It is important that these men should have a previous training in analytical chemistry of a high order, as my experience has been that it is possible to teach bacteriology to a chemist, but that the converse alternative is a waste of time. This was my own experience at Pusa with a medically-trained bacteriologist who acted for a time as my assistant, and whose qualifications as a biologist did not fit him for work as a soil bacteriologist, this being due to the very different nature of the work involved in medical and soil bacteriology. On the other hand my present three assistants who are all chemists, have shown great aptitude for bacteriological work, and their previous training as analysts has been invaluable in dealing with soil problems, which depend largely for their solution upon quantitative estimation of chemical changes in soil constituents.

Certain special problems have been dealt with during the year; these include investigations of the cause of :—

1. A bacterial disease of Tobacco occurring in Rangpur, due to the presence of a strain of Bacillus Solanacearum, differing from those described in America and Japan in its pathogenicity both for Tobacco and other Solanaceous plants, such as Tomato and Brinjal (Solanum Melongena).
2. A disease of the *Eri* silkworm associated with the presence of bacteria in the intestine; Memoirs on these two subjects are in hand. Invaluable assistance in the preparation of sections for microscopic examination in connectios with these diseases was afforded by Mr. Shaw of the Mycological Section, who was kindly permitted by the Imperial Mycologist to devote a considerable amount of time to this work.
3. The efficacy of Ratin and Trope Ratin as rat exterminators in India. Experiments were made with fresh samples received from England, and a report on the results was furnished to the Inspector General of Agriculture in India.

Ratin is a bacterial culture prepared in Copenhagen, which is intended to produce an infectious disease in rats which have fed on baits treated with it, and which then spread the contagion amongst others. Although the cultures when received at Pusa were alive, as was proved by transfers, no pathogenic effects followed when given with food to captive rats. In corresponding with the Director of the Ratin Laboratory at Copenhagen I suggested that the virulence of the cultures might be regained by cultural methods in India.

Trope Ratin is not a bacterial culture but a vegetable poison, the principal feature of which is its toxicity for rats and mice and harmlessness for other animals. Experiments proved that its efficacy in India depends upon its use within a limited period of time after its preparation, as rapid deterioration takes place with loss of toxicity. Its cost precludes any possibility of use on a large scale by cultivators, but might allow of employment in special cases, such as in granaries or warehouses.

4. A disease of *Tussar* silkworms at Chaibassa was investigated and a report submitted to the Director of Agriculture in Bengal. The general conclusion arrived at was that death was due to bacterial invasion of the alimentary canal, but that as the extent to which this developed was dependent on unsuitable diet consequent principally on climatic causes, it would be impracticable to apply preventive or remedial measures.

5. A scheme for bacteriological work in connection with the proposed dairy at Pusa was elaborated, including the idea of a course of training for students in Bacteriology as applied to dairy work.

Programme of work for 1911-12.—1. The systematic investigation of the distribution, physiological character, and functions of soil bacteria in India will be continued.

2. A special line of enquiry will be taken up as to the relations existing between the practice of green manuring in India and the activities of soil bacteria.

3. Special problems, such as plant diseases of bacterial origin, will be dealt with as occasion may arise and opportunity permit.

4. The training of the assistants in the section will be continued.

Publication.—An article on the influence of Bacteria upon soil fertility was published in the Agricultural Journal of India, Vol. VI, Part II, April 1911.

REPORT OF THE IMPERIAL COTTON SPECIALIST FOR THE YEAR 1910-11.

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

I held charge of the appointment from the 1st July to the 5th August 1910, when I proceeded on privilege leave. During my absence, Mr. S. V. Shevade, B.Sc., held current charge of my office. I resumed my duties on my return on the 6th November and continued in charge until the end of the year under report.

In July, Londa, Dharwar Experimental Station, Gokak Experimental Station and Vadgaon (all in the Bombay Presidency) were visited. In the months of August and September, Mr. Shevade visited Vadgaon, Dharwar, Gadag, Kilgiri and Kumbarganvi. After my return from leave, I visited Vadgaon and made a tour in the Central Provinces in the company of the respective Deputy Directors. Khandwa, Raipur, Nagpur and Akola were visited. In November, I also visited Dhulia and Ahmednagar. In December, I again went to Vadgaon in connection with a scheme to introduce cotton into this tract, and in January I visited Khanapur, Londa, Belgaum and Desur with the same object. In the same month I saw the cotton-experiments at Sholapur. In February, I completed my observations on cotton growing in the Deccan, at Takari and Islampur and joined the Deputy Director on tour in Gujarat, visiting Navsari, Surat and Nadiad. In March, I met the Deputy Director of Agriculture, Bengal, to advise him regarding the prospects of cotton cultivation at Chinsurah. I again visited the Experimental Stations in the Southern Mahratta Country. For the remainder of the period I was engaged in laying down a series of trials in my experimental station at Kirkee.

Central Provinces Cottons.

I visited the Experimental Station at Khandwa, where I met Mr. Evans, the Deputy Director of the Northern Division. This station is 13 acres in extent and is divided into $\frac{1}{2}$ acre plots, seven of which are devoted to cotton and five to *Jowar* and *Bajri* varieties. The experiments on cotton will be continued this year, taking in, however, only four varieties, *malvensis*, *roseum*, *Saugor Jari*, *Bhuri* and, perhaps, *Cambodia*. The following are the notes I drew out on the ground during my inspection :—

Karkeli.—This being *Hinganghat* (*Bani*) is not suited to this tract, and the fact is sufficiently proved by the appearance of the plot this season.

Malvensis is strong and vigorous and the outturn promises to be satisfactory. The staple, almost as harsh as, is longer than that of *roseum*. Which of the two will ultimately prove to be the most profitable is a point only to be determined by a test of outturn per acre. Local opinion strongly inclines to the belief that *roseum* is the more remunerative crop. This year *roseum*, being on a high-lying plot with shallow soil, cannot safely be compared for outturn with *malvensis*, which is on a lower level with deeper and richer soil.

Saugor Jari had borne its ripe bolls intact for about a month, and the White Flowered Varhadi or *roseum* also retained its ripe cotton uncommonly well. Practically none had yet fallen to the ground. The retention of the ripe cotton in the open bolls is a characteristic general to our indigenous Indian cottons.

Of *Bhuri* and *Cambodia* it can be safely said that the former is almost certain to succeed in the better classes of soil in this district. The group of cultivators, who accompanied us in the fields, concurred in my view after inspecting the crop as it stood on the ground.

Cambodia does not promise so well in the northern as in the southern cotton districts. However, to make the mat-

ter certain, it would be quite worth while to give it another year's chance.

Saugor Jari is a dwarf variety, coming so quickly to maturity that the first picking is ready this year in the middle of October. The seed was originally brought from the Rehli Taluka of the Saugor District. It is an extremely prolific cropper and appears to be suitable more especially for the poorer classes of soils, which are apt to lose moisture rapidly when the late monsoon fails as it often does in this district.

The seed obtained locally in Burhanpur has produced a crop so mixed (the mixture consisting of *Jari* with a smaller proportion of *Bani* and Upland Georgian) that the fact strengthens our conviction that, if pure varieties are established by the Department, which will then distribute them for general cultivation, methods must decidedly be devised, by home or village ginning or otherwise, to ensure that these varieties are maintained in their purity. As regards the establishment of this particular Experimental Station I foresee with satisfaction, that, being by its very nature a demonstration on an actual cultivator's land with the implements and labour supplied from his stock, the results will be readily visible to him and his neighbours.

In Berar and the Central Provinces, where cotton is usually grown associated with *Tur* (*Cajanus indicus*) more attention could be profitably paid to the cleanliness of the fields, which are infested with coarse grasses, *Celosia argentea* and other weeds.

I visited the Experimental Stations at Raipur, Nagpur and Akola in the company of Mr. Clouston, the Deputy Director, and Mr. Graham, the Economic Botanist.

At Raipur, which is beyond the cotton tracts, two plots were devoted to *Bhuri* and *Cambodia* cottons. The former gave a good crop last year and promised well for this. The Rajnandgaon Mill bought the produce at a fair price and the Manager is anxious to see the increased cultivation of this variety. It suffers from boll-worm, however, and the

general conditions of the district do not seem to be altogether favourable.

Cambodia looks unthrifty and chances are decidedly in its disfavour, but I advised Mr. Clouston to give it another trial as the rains have been abnormally heavy. Attempts to introduce the cultivation of *Deshi* cotton and *Jowar* have resulted in failure.

At Rajnandgaon we visited two fields of *Bhuri* in the company of Mr. Fredericson, the Manager of the local mill. These had done very well and the local cultivators were impressed with the result. Mr. Fredericson, however, says that *Bhuri* will not altogether serve as a substitute for American Upland, which is superior in quality. It will compete on favourable terms with the longer stapled indigenous varieties such as *Broach*, and this, after all, is a *desideratum* in the Central Provinces.

At Nagpur, Mr. Clouston still retains his plots sown from seeds locally obtained from many parts of the province and these have enabled him to gauge the nature and extent of the mixtures as they normally exist in the fields. Various high-class Uplands from American seed do not hold out promise of success. The utility of protecting cotton fields against insect attacks with girdles of *Bhendi* still seems to be a moot point, but, from my own experience, I cannot help considering that there is much to be said in its favour. Insects certainly prefer it to cotton, and if care be exercised in its destruction when its purpose is effected, much latent and active insect life must be destroyed at the same time.

The varieties of cotton actually under serious trial consist of *Bhuri*, *malvensis*, *vera*, *cutchica* and *rosea*.

In order of their value in length of staple they would stand thus :—(excluding *Bhuri*), *malvensis*,*vera*, *rosea* and *cutchica*. The last two are white-flowered forms of the two preceding them. *Malvensis* and *vera* (yellow-flowered forms) are decidedly superior in the matter of staple, but they are surpassed in percentage and total yield by *rosea* and *cutchica* (white-flowered forms). The valuations given

by the trade are practically equal for all, so, from a cultivator's point of view, the two last can safely be taken as the best to grow. Mr. Clouston estimates that he has gained from 2 to 3 per cent. in quantity by selection, and I seized the opportunity to point out to him that this is really a long step in advance, especially when it becomes established over the enormous cotton tracts of the Central Provinces and Berar.

The popular belief is that, by scientific methods, an increase in length of staple and proportion of cotton to seed can be easily attained, but the public generally and members of the Agricultural Department also should hold steadily in their view the fact that to evolve an addition of even one or two per cent. in length of staple and percentage of cotton to seed in a few years is in itself a notable feat, and that it is chimerical perhaps to hope to reach anything better. Anyhow, it would at least serve as an excellent foundation for a fresh start in advance.

Forms of all varieties with narrow-lobed leaves are more easily fixed than those with broad lobes. Undue importance should not, however, be attached to the degree of division in the leaves. At the Telinkheri farm there are plots of *Bhuri*, *Cambodia* and the indigenous varieties. All have suffered, although slightly so, from water-logging during the recent heavy rains. Cotton is a crop with a decided predilection for a well-drained soil.

The Department of these provinces is quite alive to the danger of the possibility of the reputation of their selected seed being ruined by the addition of local bazar seed by unscrupulous dealers for the sake of a temporary profit. It is difficult to conceive how such a contingency can be met in the case of indigenous varieties in which the seeds do not differ materially.

Cambodia, in all cases, seems to be inferior in strength and quality of produce to *Bhuri* in the Central Provinces and Berar, and it is also about three weeks longer in arriving at maturity, an objection of vital importance in these short season tracts.

At Akola, where a large area of the Experimental Station is devoted to the raising of selected seed, the cottons comprise *Bhuri*, *malvensis*, *vera*, *rosea*, *cutchica* and *Bani*. *Bani* has fallen into disrepute and one seed farm at Risod, especially devoted to producing its seed, has great difficulty in disposing of it. *Bhuri* seed is in rapidly increasing demand as are also *malvensis* and *rosea*, but the last-named, from its productiveness and hardiness, appeals most strongly to the cultivator. The manurial experiments appear so far to prove that farmyard manure has a distinct effect, but, that on account of their cost and trifling action there is little or practically no advantage gained from the use of artificial fertilizers. Farmyard manure and urine earth mixed give a better result than either applied alone.

All the varieties of cotton are pure now, and the chief difficulty ahead lies in the maintenance of this purity in the cultivator's fields. An accidental admixture of varieties on this station arose from the fact that whole seed was fed to the cattle and this often germinated in the manure when spread on the fields. Crushing the seed, of course, has removed this defect.

Experiments with English and indigenous ploughs and with the *Bhakar* go to prove that ploughing tends to assist water-logging in a wet season when the *Bhakar* is most effectual, but the latter method fails in a season of drought. As the cultivator can only guess what the season is going to be this conclusion is not obviously helpful. It appears to be advantageous to follow the local practice of sowing cotton in anticipation of the setting-in of the rains, and the converse applies to *Jowar*, which suffers badly if dry weather supervenes after germination.

In 1910, there were 3,000 acres of *Bhuri* under cultivation in Berar. Unfortunately the epidemic of plague greatly retarded its preparation for the market. The area actually under seed farm of all varieties is 600 acres. Three varieties of seed are supplied on purchase from this farm, namely, *malvensis*, *rosea* and *Bhuri*. At Risod in the

Hinganghat tract *Bani* is grown for distribution, but there is no call for the seed as the people are introducing the coarser, hardier and more productive *Jari* (vera) and *Varhadi* (rosea). An efficient hand gin of moderate cost and simple construction which would clean an appreciable amount of cotton per working day is an urgent necessity in the cotton tracts.

I wish here to emphasize my opinion that a real advance in the improvement of some of the staple cottons of the Central Provinces and Berar has already been effected. The cultivators show a practical appreciation of the fact by cheerfully paying enhanced rates for the selected seed supplied by the experimental stations. The chief difficulty in the future will be to maintain the varieties sufficiently pure. For some years to come the difficulty must either be met by large extensions of seed farms or by special arrangements with reliable cultivators either of villages collectively or as individual persons. At the same time steps should be taken to ensure that the cultivators receive fair rates for their improved produce.

It seems, however, too hopeful to look forward to the time when the people will realize the advantages of clean cultivation and cleanly methods of harvesting and marketing.

The British Cotton Growing Association sent the following gratifying account of the season's cottons grown at Akola :—

Value of Middling American 8·07d.

No. 1. *Bhuri.*—"Fully good middling" in grade. Staple about 1 inch. Strong. Value 7·90*d.* to 8·00*d.*

No. 2. *Bani.*—"Fully good middling" in grade. Staple about $1\frac{1}{8}$ inch. Fine, but little soft. Value 8·40*d.*

No. 3. *Malvensis.*—"Fully good middling" in grade, little stained. Staple 1 to $1\frac{1}{8}$ inch, irreguiar and rather soft. Value 8·20*d.*

No. 4. *Roseum*.—"Fully good middling" in grade. Staple rough and extremely short. Value 7*d*., quite nominal.

It is mentioned that "with the exception of the fourth sample, *Roseum*, all the samples sent are useful cottons which could be readily sold in this market at considerably higher prices than are obtained from East Indian cotton, and we hope that there may be some possibility of these cottons being produced in quantity in your district."

Bombay Cottons.

Trial with Bhuri cotton at Kumbarganvi (12 miles from Dharwar).—In March 1909, while discussing cotton matters with the Deputy Director of Agriculture at Dharwar, I suggested the possibility of a successful introduction of *Bhuri* into the tract lying in the heavy rainfall zone where land was largely left uncultivated. Accordingly a plot of about 3 acres was taken up at Kumbarganvi. The soil is shaly, and is known in local Kanarese as *Masari*, *Bhurkati* or *Rerti* in Marathi and *Gorat* in Gujerati.

The average annual rainfall is 50 to 60 inches, falling heavily from June to the end of September and more lightly till the beginning of November.

Two ploughings and three harrowings were given but no manure. The seed (obtained in 1908 from Bengal) was sown by drill at the rate of 20 lbs. per acre on the 18th August 1909. Germination was excellent and the plants were thinned out to a foot apart in the rows, which were at 2 feet intervals. The plants were soon attacked by stem borers and caterpillars. The latter were removed by hand, a difficult operation as the creatures concealed themselves during the day. This attack lasted for four weeks. It was estimated that 50 per cent. of the crop was attacked but the sequel proved that the plants received no material injury. The first picking was started on the 15th January; this gave 14 lbs. 7 oz. of seed cotton; the second was on the 25th February and gave 72 lbs. of seed cotton, the third and

the fourth on the 18th March and 1st April respectively and gave 130 lbs. (per acre 216 lbs. 7 oz.). The percentage of lint 1st picking—33·25; 2nd—34·12; and the 3rd—34·37.

The valuations showed that the resulting clean cotton was of very poor quality, the report being that it was no better than Bengals. The first, second and third pickings were valued at Rs. 280, Rs. 275 and Rs. 260 per candy of 784 lbs. Broach cotton in the same day's market being Rs. 330, Surat Rs. 345, and Navasari Rs. 360. Under normal circumstances *Bhuri* in Bengal stands at least as high as Broach. The unfavourable result was, however, instructive in that it suggested experiments with this cotton in various soils to determine the actual influence of soil on the final product.

Kulthi is probably the best rotation for cotton in this soil as it is already the custom to grow it here, and the heavy rainfall forbids the idea of growing *Jowar*. Kumpta was tried on a small plot, but, as was naturally to be expected, it was a failure.

The Cambodia cotton plants suffered so badly from the attacks of caterpillars that only a very few plants survived. They remained stunted in growth and the situation was manifestly unsuitable to them.

These two varieties were also sown on black soil at Aravadgi, about 2 miles distant from Kumbarganvi. The crops on the whole were superior to those at Kumbarganvi, but they suffered from the same insect attacks and in addition became so badly infested with Aphides that they had to be treated with spraying of kerosine oil emulsion.

Cambodia and *Bhuri* produced at Vadgaon from the same seed in 1910 were reported on by Messrs. Tata Brothers as being equal to Superfine Wardha Good at Rs. 340 and Fine Hinganghat Good at Rs. 340 respectively. This further exemplifies the effect of the soil on the quality of cotton, and trials, suggested by these valuations, are being undertaken during the present year at additional centres in order that we may ascertain the precise effects on the cotton

plant and its ultimate product induced by diverse climates and soils.

Another report from Khanapur gives a valuation of *Bhuri* at Rs. 370 and Cambodia at Rs. 340.

The 1910 crop of *Bhuri* at Kumbarganvi was valued at Rs. 380, Fine Surats of the same day being Rs. 380.

In the light of the second year's valuation it is difficult to understand why the first year's crop at Kumbarganvi should have been so inferior.

The Professor of Agriculture, Poona, kindly allowed me the use of a plot of land at Lonavla (where the average rainfall is 186·56 inches) to test the behaviour of *Bhuri*, Cambodia and *Kil* under a very heavy rainfall. The last-named, in its own home in the Garo Hills, luxuriates in almost quite as heavy a rainfall. Seeds of the three varieties were sown on the 19th June, Cambodia germinated well, but *Kil* and *Bhuri* only indifferently. The heavy rains and cold winds prevented further growth in the two latter and they died. Cambodia held out till about the end of July and finally succumbed in the heavy rain of August. It was a foregone conclusion perhaps that no cotton will withstand such heavy and continuous rainfall, but still it is satisfactory to obtain tangible proof of the fact.

Bourbon Cotton Cultivation on the Western Coast.—In former years it was demonstrated to their own satisfaction by a few enthusiasts (who probably owed their success to watchful care), that Bourbon cotton could be profitably grown in the Konkan, and sporadic plants are certainly persistent and quite common in villages. To arouse fresh interest in the subject I persuaded some Mamlatdars to induce land-owning friends to make experiments and I supplied the necessary seed. The final reports, however, proved disappointing as, owing to heavy rains, not one trial resulted in success. Now that a Divisional Inspector has been appointed for the Konkan I hope that, under his supervision, further trials with Comilla cotton, a plant from a heavy rainfall area, may show some measure of success.

Cotton Crop Experiments conducted on the Dry Farm Experimental Station of Ahmednagar.—Here we have adverse conditions under another aspect, namely, of drought and not excessive rainfall. The season on the whole was reported to be good, but the rainfall was above the average and towards the end of the season was also untimely. The germination of the seeds was therefore affected by the packing of the soil which occurs during heavy falls of rain. The subsequent resowing of the numerous gaps and more than usually rapid growth of weeds threw an excessive addition to the normal cost of cultivation. The first picking when approaching maturity was destroyed by the heavy downpour in the *Swati* rains. The plants, however, recovered, but the occurrence of a sudden frost finally destroyed the crop. *Karkeli* on the whole proved most resistant, yielding at the rate of 144 lbs. of seed cotton per acre, while 5 types of Khandesh cotton gave 94, 100, 104, 112, 114 lbs. respectively. Although due attention was paid to all the details of treatment and cultivation, no workable precautions could possibly be employed to insure the crops against the vicissitudes of such an abnormal season.

The following are valuations by Messrs. Tata Sons on samples from Ahmednagar :—

No.	Name of cotton.	Remark.	Valuation.
			Rs.
1	Karkeli . . .	Equal to F. Barsi Gd., which class is very rare or non-existent. Soft in feel and of good staple.	330
2	N. V. M. type . .	Same as above, but slightly better in staple.	335
3	N. V. K. type . .	Same as No. 1, but slightly inferior in staple.	325
4	N. V. type . .	Same as N. V. K. . . .	325
5	N. R. C. type . .	Rather rough and very short in staple ; more like Khandesh.	305
6	Khandesh . . .	This is a superior quality of Khandesh cotton, superfine in colour. The district rarely, if ever, produces such cotton.	315

Basis.—Khandesh Gd. Rs. 310 per candy of 784 lbs.

Cotton Crop Experiments on the Dhulia Experimental Station.—I visited this station on the 29th November.

The first plot of cotton inspected was labelled N. R., a selection of *Neglectum roseum* out of the types ordinarily grown in the fields. The plants were robust, the stand even and the production excellent. The staple is that of *Varhadi*. Last year the produce of this was above 900 lbs. of seed cotton per acre with a percentage of 37·5. The seed cotton is bought by the merchants at the rate of Rs. 21-8-0 per maund (144 lbs.) against the rate of Rs. 20-8-0 per local cotton.

The second plot was of N. R. C. (*Neglectum roseum cutchicum*). This is also a selection from the local cotton. The crop produced last year was 850 lbs., percentage 35. The staple is a little longer and finer than that of N. R. and the cotton was valued at Rs. 10 more per candy (784 lbs.).

The third plot was that of *malvensis*, N. V. M.; differs from *vera* proper or *Jari* in the superiority of its staple. It has been grown on a large scale only this year.

Comilla Cotton.—Fresh seed was imported this year from Hill Tipperah as the acclimatized plant had deteriorated. The lobes of the leaves are broad as well as narrow and the flowers are usually white, but some are yellow. The crop is very poor and very late.

Bhuri.—This plot looks good and productive. One cultivator at Amalner is said to have 20 acres of good *Bhuri* under cultivation. There is a rising demand for its seed and the prospects of success in Khandesh as in Berar are decidedly hopeful at present.

Cambodia looks more sturdy than *Bhuri* but it is a later crop. The prospects of both are of course uncertain until they have been subjected to the experience of a dry season. The cultivator at Amalner, already mentioned, has obtained from the merchants Rs. 10 per maund (144 lbs.) of seed cotton over the price of local cotton.

Of the crosses, that of *Comilla* with *Bani* is most promising as regards both quantity and quality. The selected

plants yield a staple over $\frac{3}{4}$ inch and ginning percentage of about 33.

Karkeli is not very promising, but still it yields a profit quite equal to that of the local crop.

Bani from Akola looks well, but it will never be a favourite crop in a tract where the cultivators prize the qualities of hardiness and high percentage of cotton.

Neglectum var. *kathiawarensis*.—The growth is very vigorous and prolific. Last year it yielded 741 lbs. of seed cotton per acre, with a percentage of 27·10.

The following are some of the results obtained on the station :—

Name	Seed cotton per acre.	Percentage.
Neglectum *var.* malvensis . .	686	26·10
„ „ vera . . .	729	30·00
„ „ cutchica . .	780	35·50
„ „ rosea . . .	870	37·50

Inter se crossing in *Bhuri* and Cambodia has produced enormously strong plants.

As in the Central Provinces and Berar so also in Khandesh the same difficulty in the distribution and maintenance of the pure varieties has to be surmounted. So far there is only one demonstration plot, *viz.*, at Amalner, where the different types are grown. There is also a demonstration held at the Experimental Station every October and this had the desired effect of introducing the improved varieties to the attention of the cultivators who send in orders for seeds. In the local practice, seeds are sown through two tubes placed behind and dragged after the *bhakar*. This requires the attention of three people while the Gujerat drill (which is being introduced) only requires two. The Gujerat bullock hoe is also said to be more effective, as it brings the earth better round the plants.

The Manager of Messrs. Volkart's Spinning and Pressing Factory informed me that he was buying extensively pure supplies of the very coarse *Varadi* (*roseum*) cotton which he considers does really possess a staple. He says that this cotton is mostly used in Germany, Austria and Hungary and that *Bengals* are used in Italy. Fraudulent practices are obviously carried on by cultivators. Wet and damaged cotton is packed into the centre of finer stuff and much leaf and dirt is present. The dry, brown leaf is not so objectionable because it can be blown away, but it is difficult to free the cotton from the black leaf caused by damp.

Khandesh cotton seed bears a good reputation in the European market, its refraction being only 6 per cent. while that from Berar is $6\frac{1}{2}$ to 7.

The cultivators, as a rule, do not take away the seed during the ginning season, but just before sowing time, when they have made up their minds as to what they are to grow, they take whatever they can get in the shape of seed from the mounds in the compounds of the ginning factories. A few of the more careful cultivators, however, especially those who farm on a large scale, bring their seed cotton to the ginning factory, see it ginned in their presence, and often sell it during the process to the highest bidder. They take away there and then what they require for the next season's sowing.

Cotton Experiments at Sholapur.—I visited these in January in company with Mr. Patil, the Divisional Inspector of Agriculture. The first plots seen were at Mohanmala on land owned by the late Rao Bahadur Warad. These experiments were started last year with the object of ascertaining the mixture existing in the cotton fields of the Sholapur District and also the value of the component parts of such mixtures.

The seeds were collected from all the talukas of the district. Mr. Patil has separated out these types and furnished the following analysis :—

A statement showing the Analysis of Cottons in the Sholapur District, 1910-11.

NEGLECTUMS.

Plot No.	Name of village from which the seed was obtained.	Name of Taluka.	Total No. of plants in each plot.	White flowered broad lobed.	Yellow flowered broad lobed.	White flowered narrow lobed.	Yellow flowered narrow lobed.	Broach.	Upland Georgian.	REMARKS.
1	Peha	Pandharpur	166	·6	63·25	1·8	17·46	·6	16·26	
2	Jeur	Karmala	123	0	23·57	·81	10·56	63·4	1·06	
3	Tadola	Barsi	93	0	69·9	6·15	13·9	4·36	5·37	
4	Pomalwadi	Karmala	74	0	40·5	1·3	10·8	40·5	6·7	
5	Tembhurni	Ditto	49	0	59·18	2·03	14·3	18·3	6·1	
6	Malshiras	Malshiras	75	0	76·0	1·0	14·6	1·0	1·3	
7	Akluj	Ditto	88	0	58·0	3·4	6·8	25·0	6·8	
8	Vairag	Barsi	51	0	80·4	0	9·8	5·88	3·92	
9	Sangola	Sangola	36	0	55·5	0	19·44	2·8	22·2	
10	Bhalani	Pandharpur	83	1·2	56·6	0	20·4	14·4	7·2	

I understand from Mr. Patil that the experiments are to be transferred to Karmala, about 12 miles from Jeur Station. The villagers there have lost their crops through the use of unsuitable seed obtained locally from ginning mills. The cotton usually grown by them is a mixture of neglectum with a little Jowari Hatti and Upland. The people prefer the narrow-lobed neglectum and say that they are willing to buy up any quantity of seed. The rainfall is said to be precarious and the methods of cultivation poor so that the locality seems altogether unsuitable for high class cottons. I have recommended that pure varieties of neglectum be obtained either from Dhulia or from Akola. We have since sent 1,300 lbs. of Varhadi seed to Mr. Patil, also 150 lbs. of Saugor-Jari seed, an early ripening dwarf, prolific variety, which ripens its crop at least three weeks in advance of Jari and Varhadi: I also visited Pasare's Estate on which the Department is working with manurial experiments.

The following are valuations by Messrs. Tata Sons on samples sent from each of the treated plots :—

No.	Description of sample.	Report.	Price per candy.	Remarks.
			Rs.	
1	Plot manured with F. Y. manure.	Strong in fibre and of good staple and has the appearance of the usual cotton of the Sholapur District.	335	Western style.
2	Plot manured with pot-sulphate and superphosphate.	Weaker in staple than No. 1 .	325	Ditto.
3	Plot manured with ammonia sulphate and superphosphate.	Staple and strength of fibres between Nos. 1 and 2.	330	Ditto.
4	Manured with superphosphate.	Equal to No. 1 . . .	335	Ditto.
5	Manured with ammonia sulphate only.	Equal to No. 3 . . .	330	Ditto.
6	Check plot; no manure .	Equal to No. 1 . .	335	Ditto.
7	Manured with pot-sulphate only.	This is the best of the whole group in colour, length of staple and strength of fibre.	340	Ditto.
8	No manure; check plot .	Equal to No. 1 . . .	335	Ditto.
9	Manured with ammonia sulphate, superphosphate and pot-sulphate.	Equal to No. 2 . .	325	Ditto.
10	No label . . .	Equal to No. 1 . . .	335	Ditto.

Basis.—Good Western Gd., Rs. 335.
Fine Broach Gd., Rs. 360.

Again, in company with Mr. Patil, I visited the experiments with Broach cotton (seeds imported from Navasari last year) near Islampur in the Krishna Valley. This is a highly cultivated and fertile tract and agricultural operations have been very carefully attended to.

In the first field local Jowari Hatti and the imported Broach are growing side by side. The former was ripening, while the latter bore only flowers and unripe bolls.

In another field of imported Broach, sown in June, the bolls were ripening. From the conditions of these two trials one sown in the end of July and the other in June, it is plainly obvious that no delay should occur in the sowing of Broach cotton in this district. I also suggested the trial of *Bhuri* and Cambodia in this tract.

The following are valuations of local Jowari Hatti and Broach cotton grown in adjacent plots on these trials :—

No.	Report.	Price per candy.	Remarks.
		Rs.	
1	If the seed is Bengal, it has certainly improved in Islampur soil and looks more like Miraj cotton.	335	Western style.
2	Same remark as above ; it is better in colour than No. 1 .	340	Ditto.
3	Shows deterioration in colour only	390	Surat style.
4	Better than No. 3 in colour, but slightly shorter in staple .	385	Ditto.

N.B.—Nos. 1 and 2 are Jowari Hatti; Nos. 3 and 4 are from seed imported from Navasari.

Basis of valuation per candy :—
Fine Surat Gd., Rs. 380.
„ Broach Gd., Rs. 360.
Good Western Gd., Rs. 335.
(Candy of 784 lbs.)

Some experiments are being conducted at Nadiad in the Kaira District to solve the very difficult problem of finding a better cotton than the local Rosi.

Three varieties are at present under trial; Bourbon, *Bhuri* and Cambodia :—

Bourbon.—This was the second year of its growth. During the first year it yielded 400 lbs. of seed cotton per acre, second year, 1,000 lbs. of seed

cotton per acre. The second year's growth was extremely satisfactory, so much so that the branches had intermixed and it was impossible to go into the field. It remained to be seen whether after pruning (third year) the outturn is maintained.

Bhuri.—This was sown in May under irrigation only until the rains broke; outturn 1,100 lbs. of seed cotton per acre.

Cambodia.—Sown in May under irrigation like Bhuri; outturn 800 lbs. of seed cotton per acre.

It seems that both *Bhuri* and Cambodia should be established before the rains to reap a good harvest. It was gathered that cultivators from the neighbourhood occasionally visited the farm and were satisfied with the growth, outturn, etc., and as a consequence of this the Superintendent has received many requisitions for the supply of seed of all the three varieties mentioned above.

Samples were valued by Messrs. Tata, Sons & Co. as follows :—

	Rs.	
Fine Surat	380	per candy of 784 lbs.
Navasari	400	
Fine Broach	360	

Valuation of Nadiad Samples—

Bourbon—Equal to F. Navasari Gd., good in colour and staple, Rs. 400.

Cambodia—Equal to F. Broach Gd, but better in staple, Rs. 365.

Bhuri.—Equal to F. Broach Gd., Rs. 360.

From these valuations it will be seen that there is a strong possibility of at least three high class cottons being introduced profitably into Northern Gujerat.

Full reports of the cotton operations on the Bombay Experimental Stations will be found in the Progress Reports. Mr. Keatinge, the Director of Agriculture, in a recent note has clearly shown the present condition and prospects of cotton cultivation in the Bombay Presidency. This is entitled "Note on Improved and Exotic Cottons in the Bombay Presidency." It should be carefully studied by all who are interested in the improvement of Indian cottons.

Madras Cottons.

Good work is being done in the Southern Districts of the Presidency judging from the samples of selected cottons which were sent to me for valuation.

These were adjudged by the Directors of the Bombay Cotton Association, Limited, who remarked that all the samples showed nice clean cotton and the differences in price is all practically due to staple. That the Karunganni samples are *more* suitable for weaving mills than the Uppam samples, but both styles should suit buyers for export and local consumption.

The following is their detailed report :—

Samples of cotton from Madras submitted by the Imperial Cotton Specialist :—

	Rs.
Basis—Fine M. G. Broach	350
,, Fine M. G. Navasari	375
,, Fine G. F. Tinnevelly	345

Serial No.	Description.	Approximate market value in Rs. per candy of 784 lbs. less 5½ per cent. discount.	Remarks.
	Uppam Variety.		
1 U	Ordinary field crop . . .	335	Rather harsh in staple ; very clean.
2 U	Pedigree Uppam	340	Staple rather better than No. 1.
3 U	Ditto	340	Ditto.
4 U	Ditto	335	Ditto.
5 U	Ditto	335	Ditto.
6 U	Ditto	345	Ditto.
7 U	Ditto	340	Ditto.

Serial No.	Description.	Approximate market value in Rs. per candy of 784 lbs. less 5½ per cent. discount.	Remarks.
	Karunganni Variety.		
1 K	Karunganni ordinary field crop .	345	Silky staple.
2 K	Pedigree Karunganni . . .	345	Ditto.
3 K	Ditto	345	Ditto.
4 K	Selected Karunganni . .	345	Ditto.
5 K	Ditto	343	Ditto.
6 K	Pedigree Karunganni . . .	350	Ditto.
7 K	Ditto	345	Irregular in staple.
8 K	Ditto	345	Staple rather irregular.
9 K	Ditto	350	Staple good and silky.
10 K	Ditto	340	Ditto.
11 K	Ditto . .	345	Ditto.
12 K	Ditto	370	Long silky staple, excellent, spinning cotton.
13 K	Ditto	370	Ditto.
14 K	Ditto	375	Ditto.
15 K	Ditto	380	Ditto.

It will be seen from the above that the selections have been valued almost in their correct order by Mr. Sampson.

Bengal Cottons.

I visited the Experimental Station at Chinsurah and furnished the following report, which was based on an inspection and discussion with Mr. Smith, Deputy Director of Agriculture.

The first plots seen were of Cambodia and Bhuri cottons, one-fifth of an acre each. These were on well-drained raised land and their condition was very satisfactory indeed. As explained to me, I gathered that this class of land is very rare in the province, its height above the general level being due to an accumulation of silt and weeds thrown up while excavating tanks. It is the most suitable of soils for plantains, etc., and we can scarcely expect a cotton crop to compete with these in value. The second series of plots visited were of the same cottons on paddy land, lying at the general level. The plants were unthrifty and showed distinct signs of damage by water-logging earlier in the sea-

son. Practically no crop had been produced and the immature bolls were shrivelling. The plots of indigenous varieties were only just coming into flower. This means that bolls could only be ripened during the hot weather, and as their produce at the best would only be equal to the most inferior Berar or Khandesh cotton, they are scarcely worth troubling with in a tract which grows more highly remunerative crops, such as rice and jute. *Deshila* and *Bhogila* are still later and the length of time they occupy the ground is a serious objection to their cultivation. It is to be regretted that the primitive people of Chutia Nagpur cannot be induced to extend the cultivation of Bhuri cotton in their country, but, so far as they are concerned, there is probably no material incentive for them to so exert themselves.

All the Indian varieties of cotton have now been tried in the deltaic area of Bengal, and the inevitable conclusion to be drawn from the experience thus earned is that the conditions of soil and climate are not in any way suitable for cotton cultivation, and I cannot recommend that experiments with a view to introduce their culture should be persevered with.

The following samples from Chinsurah, Bengal, were kindly reported on for me by Messrs. Tata, Sons & Co. of Bombay :—

No.	Name.	Report.	Price per candy.	Remarks.
			Rs.	
1	Cambodia . . .	The cotton has preserved its silkiness and staple, but has deteriorated in class. It is F. G. in class.	300	Bengal style.
2	Bhuri	Better than No. 1 . .	310	Ditto.
3	Deshila	Very much deteriorated, and is like G. Bengal.	275	Ditto.
4	Bhogila	Deteriorated and can be likened to F. G. Bengal.	285	Ditto.

Basis per candy of 784 lbs. —
F. Bengal, Rs. 315.

It will thus be seen that no very remunerative cotton has as yet been established in Bengal.

Punjab Cottons.

Excellent results are being attained by Mr. Milne, the Economic Botanist, as will be seen from the account published in his progress report and by the British Cotton Growing Association, Manchester. It was considered that 161 A. F. was the best, while Pride of Georgia coming second is nearly equal by 199 F., 220 F., and King's Cotton is slightly lower than the last three. The reports on the indigenous cottons are not so favourable. It is to be hoped that the extension in the cultivation of the higher class cottons in the Punjab will be persevered with.

Valuations.—All samples received were submitted to Messrs. Tata, Sons & Co., Bombay, for valuation. Cordial acknowledgment is due to these gentlemen for their kindness and promptitude in giving opinions on cottons whenever submitted to them.

Some samples were also submitted to the Bombay Chamber of Commerce, to whom thanks are also due.

Programme of work for 1911-12.—1. To visit and advise on points regarding cotton and its cultivation whenever requested to do so by Provincial Departments of Agriculture.

2. By special invitation of the Department of Agriculture, Punjab, to report on the work done in the way of cotton improvement in that province. The question of the distribution of seeds of improved varieties will be further discussed with the proper authorities in the Central Provinces and Bombay Presidency.

3. The study of the behaviour of Bourbon, *Bhuri*, and such other cottons in non-cotton producing tracts as detailed in my last year's programme will be continued.

4. The conditions of cotton cultivation in Kathiawar and adjacent parts would be investigated.

5. An enquiry will be commenced on the manurial requirements of cotton.

PUBLICATIONS.

Article on Caravonica Cotton. Agricultural Journal of India, Vol. V, Part III.

The present position and prospects of Cotton Cultivation in India. For the International Congress of Tropical Agriculture, Brussels, May, 1910.

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REPORT

OF THE

Agricultural Research Institute and College, Pusa

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

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Report of the Agricultural Research Institute and College, Pusa,

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

1911-12.

REPORT OF THE DIRECTOR.

(B. Coventry, C.I.E.)

1. *Charge.*—Dr. E. J. Butler held charge of the office of Director, Agricultural Research Institute, and Principal of the Agricultural College, Pusa, in addition to his own duties of Imperial Mycologist till the end of March 1912. At the end of the financial year 1911-12, the two posts of Inspector General of Agriculture in India and of Director, Agricultural Research Institute, Pusa, were amalgamated into one of Agricultural Adviser to the Government of India and Director of the Agricultural Research Institute, Pusa. Since that date, I have held charge of the combined offices. Mr. A. C. Dobbs, who was formerly Assistant Inspector General of Agriculture in India, held the post of Assistant to the Agricultural Adviser to the Government of India till 28th April 1912, when he proceeded on six months' combined leave.

2. *Staff and work of the Institute.*—The work of the Institute as carried on in the seven scientific sections into

which it has been organised has been detailed in the reports of the several sections which are embodied in this report.

The Chemical Section was in the charge of Dr. J. Walter Leather. Mr. H. E. Annett, the Supernumerary Agricultural Chemist, was, till November 6th, 1911, on deputation to the United Provinces Department of Agriculture, to act as Principal of the Cawnpore Agricultural College. He left Pusa again on 9th May 1912 to act as Agricultural Chemist to the Government of the Punjab.

Mr. A. Howard was in charge of the Botanical Section. From July to September 1911 and during May and June 1912, he was at Quetta in connection with the development of the Fruit Industry in Baluchistan. The services of Mr. E. Holmes-Smith, the Supernumerary Botanist, were terminated on 7th October 1911.

The Mycological Section was in charge of Dr. E. J. Butler, throughout the year except from 17th June to 6th July 1912, when he was on privilege leave: during this period Mr. F. J. F. Shaw, the Supernumerary Mycologist, officiated for him.

Mr. H. Maxwell-Lefroy, the Imperial Entomologist, was on long leave throughout the year. Mr. T. Bainbrigge Fletcher, Supernumerary Entomologist, held charge of the section until April 19th, 1912, when he proceeded to Coimbatore to take up the new appointment as Entomologist to the Government of Madras. Mr. A. J. Grove joined his appointment as Supernumerary Entomologist on October 27th, 1911, and since Mr. Fletcher's transfer to Madras, has carried on the work of the Entomological Section.

The designation of the Second Imperial Entomologist has been altered to that of Imperial Pathological Entomologist, and Mr. Howlett held charge of the section throughout the year.

The Bacteriological Section was in charge of Mr. C. M. Hutchinson.

The Agricultural Section continued under the charge of Mr. A. C. Dobbs, until April 27th, 1912, when he proceeded on leave. Mr. S. Milligan, Deputy Director of

Agriculture, Punjab, has been transferred to this Institute to take up the post of the Imperial Agriculturist. He joined the appointment on May 8th, 1912. Mr. H. Southern, Supernumerary Agriculturist, who had been officiating Deputy Director of Agriculture, Madras, was transferred to the Punjab in April last to take up the appointment vacated by Mr. Milligan. Mr. G. D. Mehta was appointed Supernumerary Agriculturist on 4th June 1911. Until 30th May 1912 he was working at Poona under the Government of Bombay and from that date he has been posted to the Central Provinces for training. Messrs. W. S. McGowan and Thomas Gilbert were appointed Supernumerary Agriculturists on 23rd February 1912. The former is posted to Bihar and Orissa to act as Professor of Agriculture at the Agricultural College, Sabour, and the latter is working under the Government of Bombay.

3. *Agriculture.*—The rainfall during the year amounted to 56·30 inches. The monsoon arrived early and gave a plentiful rainfall. Floods, however, damaged the *kharif* crops, while late rain retarded the sowing of the *rabi* crop. The permanent manurial and rotation experiments started in 1908 with the object of studying the maintenance of the fertility of the soil have been continued. It is too soon yet to expect definite results from these experiments. The improvement of the sugar-cane crop on the ridge and furrow system combined with intertillage has been taken up and promises to be an important advance upon the methods in vogue in North India. It is proposed to apply the same system in a modified form to some of the *kharif* crops such as maize, which have already shown great improvement from liberal spacing and intertillage as well as from the free drainage induced by ridging. Among the use of chemical manures the application of crude sulphate of soda to paddy gave an increase of 17 maunds of grain per acre. This is a preliminary result requiring confirmation. The application of green manuring with *san* hemp combined with the moderate application of superphosphate at the time of sowing the *san* continues to give good results and is

the chief means by which the fertility on the farm is maintained against heavy and continuous cropping.

A new and important feature in the experimental work on the farm is a series of plots in which the biological factor connected with the use of green manuring as well as other bacteriological problems will be studied by the Imperial Agricultural Bacteriologist in conjunction with the Imperial Agriculturist. Too much stress cannot be laid on this work, which is now generally recognised as affording a most promising field for research into the principles underlying the fertility of soils.

4. *Chemistry.*—The work on the availability of plant food in soils and that of the moisture requirements of crops to which reference has been made in previous reports is being continued. The examination of water after passing through certain depths of soil continues to be carried out. It has been observed that not only is there less nitrate in the drainage water from the cropped soil than from fallow land, but the deficiency could not be accounted for merely by assimilation by the crop. Dr. Leather, therefore, deduces that either less nitrate was formed in the presence of the crop or some other agent than the crop was assimilating the nitrate. The investigations in *Usar* soil which have been going on for some years have so far not led to any very useful nor definite results.

In the last Annual Report mention was made of the investigation into the date-palm sugar-industry which was carried on by Mr. Annett, the Supernumerary Agricultural Chemist. This has been continued during the past year and has led to an accumulation of very valuable information on the subject, which is now in the press and will soon appear as one of the Memoirs of this Department. Besides recording the history of this industry Mr. Annett gives a good description of the cultivation and tapping of the palm and the manufacture of the raw and refined sugar. He found that the juice contains 8 to 10 per cent. of sucrose, associated with practically no glucose. This fact indicates that it is an exceedingly good materials for the production

of white sugar direct from the juice. Owing, however, to imperfect methods of collection, 1 to 2 per cent. glucose is formed during the night and this amount is again greatly increased by the subsequent primitive treatment, thereby occasioning very great loss in white sugar. In an account of this work Mr. Annett draws attention to the great improvements which have been introduced into the corresponding American Industry of Maple Sugar, though in this case the juice which forms the raw material contains only 3 per cent. of sucrose. If improved methods could be applied to the Indian Palm Sugar Industry, there is no doubt not only that it would add to the profits of the sugar maker, but that the white sugar produced would assist to some extent in checking the encroachment of foreign white sugar into this country. The importance of this problem can be gauged by the fact that the production of sugar from the palm tree in India amounts to some 480,000 tons.

Some important work has been carried on in the Chemical Section during the year in the endeavour to establish a reliable method of milk tests for Indian cattle. When testing cows' milk in India two sources of error have to be guarded against; (1) if the periods between milking are not equal, the composition of the milk will be influenced, and (2) the calf will take an indefinite amount of milk if this is not controlled. In order to eliminate these sources of error the cows are milked exactly at intervals of 12 hours, and the calf is allowed to take the whole of the milk from only two teats on one side of the udder, the other side being milked by hand and the calf being made to change the side every 24 hours. In this way the difficulties described were overcome. While great regularity was as a rule obtained in the composition of the milk, yet it was possible to observe characteristic differences. The chief of these was that the percentage of butter fat in the morning was greater than that in the evening milk by ·5 to 1·5 per cent. and there was no exception to this rule. No systematic difference was found, in the composition of the milk, between the different sides of the udder.

5. *Botany.*—The wheat work continues to absorb a very large portion of the time of this section. The extended trials of the past year go to confirm previous results, and give prominence to the important fact that high yielding power and good grain qualities can be combined in the same plant. Stress is again laid upon the need of good cultivation and the repeated favourable results obtained therefrom entirely warrant this. As so much of the wheat exported from India is grown under irrigation it was important to ascertain by experiment whether wheats of good quality and high yielding power could be obtained in the canal districts. This has been done. Extended trials of the Pusa wheats have been made at Cawnpore and yields of over 2,200 lbs. per acre and in one case of 2,500 lbs. were obtained with a single watering. That is to say it was obtained with one-third of the water usually used by the cultivators in the neighbourhood. As regards quality they were found to possess baking qualities equal, if not superior, to the wheats grown at Pusa without irrigation. Mr. Howard, in this year's report, gives detailed accounts of the results of the extensive trials which were made of his wheats, in the wheat tracts of India, to which reference is invited. Owing to the success of these experiments, a great demand has arisen in various parts of India for the new wheats. Arrangements have, therefore, been made, to grow during the coming season, a large stock of seed, which it is expected will meet all demands.

Experiments on the influence of the environment on the quality are being continued and extended, with the object of finding out how far high quality in grain is possible in different wheat tracts. If wheat of good quality such as has been grown at Pusa and Cawnpore could be grown in any of the wheat tracts of India, the fact would be of very great importance, as the Indian wheats of commerce are mostly of poor quality. So far wheats grown on such varied soils as the alluvium and the black cotton soil did not lose their milling and baking qualities. Mr. Howard likewise maintains that in any particular wheat the condi-

tions which produce the highest yield are those which produce the best quality.

Not by any means the least important aspect of the work on wheat is that of breeding. Rust resistance, high yield, and strong straw in order to carry a heavy weight of grain are points to which attention is being particularly devoted.

Amongst other important investigations are those connected with the tobacco plant. The object of these experiments is to endeavour to establish a suitable plant for the manufacture of cigarettes, which are fast supplanting the *hooka*. Three types Nos. 28, 29 and 32 were grown and were cured by a slight modification of the country method. The whole of the crop was sent to the Peninsular Tobacco Company at Monghyr and made into cigarettes. Type 28 was very well reported on and was valued at from Rs. 12 to Rs. 14 per maund which is a considerable advance on local prices. Arrangements are now being made to repeat these results if possible amongst the cultivators.

Gram is another important crop to which Mr. Howard has been giving his attention, and he has shown by preliminary trials that there exists a very large margin on which to work out improvements both in yield and quality. Thus as the result of samples sent to Messrs. Ralli Brothers one variety was valued at Rs. 4-8-0 per cwt. and another at Rs. 5-8-0 per cwt. as compared with the price of Rs. 4-2-0 of the ordinary export varieties. The yields too were extraordinarily high being over 30 maunds per acre.

The work on the botanical characteristics of fibre plants and the study of the methods of pollination in the various Indian crops are being continued.

The development of the Fruit Industry of Baluchistan is a piece of work which is now assuming important proportions, and a fruit experiment station has been established about two miles from Quetta. It will take some little time before the model fruit garden comes into bearing, but in the mean time an old fruit garden has been taken over and improvements are being applied to it. The questions of packing and transport are being thoroughly gone into and

the results of the past season's experiments give promise that the cheap, quick and safe transit of first quality fruit to any part of India will soon be an accomplished fact.

6. *Mycology.*—An investigation is in progress into the disease of paddy known as *ufra* which is causing great damage in the Noakhali and other districts of Eastern Bengal. At first it was not known whether it was caused by a fungus, an insect, or some other cause. A conjoint entomological and mycological investigation resulted in the exclusion of insects as the direct cause and suspicions have been thrown upon an eel-worm so small that it is barely visible by the naked eye. It is estimated that in the Begumganj Thana alone, in the Noakhali district, some 200,000 maunds of grain was destroyed in 1910, and last year about half the crop was destroyed. The disease also occurs in Comilla, Chandpur, and the neighbourhood of Dacca. Dr. Butler, the Imperial Mycologist, is devoting special attention to this disease.

Mr. F. J. F. Shaw, the Supernumerary Mycologist, has devoted a great deal of attention to the rot induced by the soil-dwelling parasite known as *Rhizoctonia*. Its existence is very widespread, and it attacks crops such as potatoes, jute, groundnut, cow-pea and cotton, though so far cereal crops fortunately appear to be immune to this disease. Good tillage and a suitable rotation of crops are thought to be the best ways of preventing its ravages.

Further work has been done on wheat rust, which is a serious disease in this country in certain years. Thus there was last year a severe attack in the Central Provinces, the first for a number of years. The damage was caused by the variety known as " Orange " rust (*Puccinia triticina*) and much of the loss in 1912 must be attributed to it. In breeding rust resistant wheats therefore, for the Central Provinces, Dr. Butler is of opinion that this variety of rust should be taken into account, as well as the " black " rust (*Puccinia graminis*) which does much damage in normal years. The variety known as " yellow " rust (*Puccinia glumarum*), does not appear to be of importance. Diseases due to *Phytophthora*, Sugarcane diseases, among others one

resembling *Sereh* and occurring on the Jorhat Farm in Assam, the Betelnut Palm disease, the Indigo disease and other diseases, connected with tea, cotton and coffee, as well as diseases of forest trees, have engaged the attention of this section during the year.

A very large amount of systematic work has also been done, and some hundreds of specimens, of plant parasites for the most part, have been added to the named herbarium collection. Two parts of the list of Indian fungi were prepared in collaboration with Messrs. H. and P. Sydow of Berlin, and published—containing some 300 species of Indian fungi, of which more than a hundred were new to science.

7. *Entomology.*—In Madras a campaign has been carried out against the Deccan Grass-hopper. The method known as "bagging" was adopted, more or less successfully, and the ploughing of infested lands was carried out. Besides this a leaflet was issued in English, and in the vernacular, giving a description of the methods to be adopted against this pest. Experiments against White Ants were continued in the Central Provinces. The application of kerosene oil was found most effective in dealing with the mound-building variety of termites. The collection and despatch to the Punjab of parasites of the cotton boll-worm formed an important aspect of the work of the section, as dependence is placed upon this parasite in order to keep in check the ravages of the insect. This method of controlling this pest is being adopted in Egypt, and parasites have recently been sent to that country for this purpose. A leaflet has been issued in the vernacular explaining how this remedy should be used. In the United Provinces measures have been adopted against the Rice Grass-hopper which has become a serious pest of sugar-cane in that province. The method of storing seed potatoes in sand as a protection against the Potato moth was successfully demonstrated to cultivators in Bengal. At Mokameh a campaign was organised against *Agrotis ypsilon*, a caterpillar which has been destroying the crops in that region. The picking off

of the first brood of caterpillars and the setting up of the Andres-Maire traps reduced the damage to such an extent that, out of a total area of 20,000, only 2,000 bighas were affected.

Sericulture has continued to claim a large amount of the attention of the section. Experiments are in hand for crossing the Indian multivoltine variety of mulberry silk-worm with the univoltine races from Europe, with the object of producing a superior silk-producing multivoltine hybrid. If this work is successful it will go a very long way towards placing the Indian silk industry, now in a precarious position, on a more stable footing. Eri-silk culture, Lac-culture and Api-culture continue to occupy the attention of the section.

8. *Pathological Entomology.*—This section, which was formerly styled the Second Entomological Section, now confines its attention to entomological work connected with the diseases of men and animals, and its name has in consequence been changed. Its relation with medical work has now become much closer, and, through the good services of the Medical Research Fund, the addition of three posts has been made to the subordinate staff. These extra men will be occupied exclusively with Medical Entomology, while there will be two men available for Veterinary and general work.

Special attention has been paid to the genus *Stegomyia* and allied forms of the mosquito owing to the possibility of importation of Yellow Fever into India from the Panama Canal, and a course of instruction has been given to medical officers belonging to the "Stegomyia Survey." Investigations are in progress on the influence of temperature, range of flight, food, breeding places, etc., and on the natural enemies of mosquito-larvæ.

The other subjects that are receiving attention are the breeding places and habits of *Phlebotomus*, the life history of the Crab-louse, the parasites of *Tabanus albimedius*, *Monophlebus stebbingi*, and the life history of *Celyphidæ*. The East Indian Railway school at Jharipani was success-

fully rid of a plague of bugs by the application of hydrocyanic acid.

9. *Bacteriology.*—The principal work of this section during the past year has been the study of the factors which determine the biological activity of Indian soils, and the devising of methods by which this activity may be ascertained and measured. The usual plan of estimating bacteria by "plating" has been abandoned in favour of the measurement of their resulting physiological activities. Thus, for example, it has been ascertained that the biological activity of a soil is in direct proportion to the rate of formation of carbon dioxide, and that conditions unfavourable to the former will also adversely influence the latter. It is possible in this way to determine the optimum conditions of moisture content, the effect of the addition of various manures, organic and mineral, and the influence which tillage will have upon any particular soil. The biolysis of green manures, root residues, and organic manures, in so far as they form the supply of available nitrogen, has been undertaken.

It has been found that important differences exist in the biological changes that take place in Indian and European soils. These differences appear to be due mainly to the relatively higher temperatures and consequent greater bacterial activity of Indian soils. At temperatures between 15° C. and 18° C. the formation of ammonia is in proportion to the nitrification which follows it, but when temperatures rise from 25° C. to 30° C. ammonification may proceed with such rapidity that nitrification is interfered with, and even inhibited altogether, by an excess of ammonia. If, therefore, large quantities of organic matter are applied to a soil, much nitrogen may be lost in the form of ammonia—which shows the necessity that exists for selecting the most suitable time of year for applying organic manures. It has also been ascertained that where intense bacterial action is taking place in a soil, nitrates present will be reduced, without the occurrence of anærobic conditions, lending support to the belief that the nitrate is

utilised as a source of nitrogen by the bacteria themselves. These considerations tend to show what great care should be exercised in a tropical country like India in the treatment of the soil, if its supplies of plant food are not to be dissipated or wasted, and it also confirms the opinion which is now ripening into positive fact, that the study of the biologic factor in soils is of supreme importance, and that very important results are to be expected from it.

A special enquiry, also, is proceeding into the conditions determining the formation of bacterio-toxins in soils, and into their effect on crops.

10. *Training.*— The training of students on the lines laid down in the Prospectus was continued, and short courses were also given in Cattle and Poultry management, Sericulture and Lac cultivation. Of the two post-graduate students in Agricultural Chemistry, admitted in the previous year, one continued his course, but the training of the second was terminated, as he was considered not likely to prove himself an efficient assistant. The two students in Entomology, mentioned in the previous year's report, left during the year: one after completing his course, and the other before its completion, as he was recalled to his province. The Assistant Director of Agriculture, Punjab, who was deputed to this Institute for a two years' course in general agriculture, completed his training on 21st August 1911, and returned to his province.

During the year under report four new students were admitted for training in Agricultural Chemistry. Of these, two are Government stipendiaries (one from Bengal and one from the Travancore State) and two are private students. A private student deputed by the Department of Agriculture, Travancore, was admitted, for training in general entomology. The Agricultural Department of Bihar and Orissa have deputed an Entomological and Mycological Collector for training in Mycology and Entomology. One advanced student from the Agricultural Department of the Central Provinces was given training,

in the Botanical Section, from October 1st, 1911, to the end of April 1912.

During the year under report, 33 students attended the short courses—two in 'Cattle management,' one in 'Poultry management,' seventeen in 'Sericulture' and thirteen in 'Lac cultivation.'

11. *Buildings and Works.*—During the year under report two small supplementary Laboratories were constructed, departmentally, for the use of the Imperial Agricultural Bacteriologist and the Imperial Pathological Entomologist, respectively. Residential quarters were also constructed for the use of the Superintendent of the Office of the Agricultural Adviser.

12. *Library.*—The Library is rapidly becoming overcrowded. Proposals for its extension have been submitted. During the year under report about 1,400 volumes have been added.

13. *Publications.*—The issue of the Journal, Memoirs and Bulletins was continued. The Department published during the year 14 Memoirs and 4 Bulletins, against 7 Memoirs and an equal number of Bulletins in the previous year. As noted in the last year's report, the Provincial Departments are supplying an increasing volume of contributions for these publications.

In consequence of the abolition of the Journal of Tropical Veterinary Science from 1st April 1912, it has been decided that articles of a popular character on veterinary subjects should be inserted in the Agricultural Journal of India. Contributions unsuited for the Journal, by reason of their being too technical, will be published in the form of Veterinary Memoirs which are now among the Scientific Memoirs issued by the Agricultural Department. They will be issued from time to time as matter becomes available. The editing committee has been strengthened by the appointment of the Imperial Bacteriologist, Muktesar, as a co-editor. The grant for the agricultural periodicals and Journal, which was curtailed

during the previous year to Rs. 23,000 remained unaltered during the year under report, but the Government of India have added Rs. 2,000 for Veterinary Memoirs, so that the total grant for publications now amounts to Rs. 25,000. As the work of the Department expands the matter for publication likewise increases, and the present grant will not be sufficient. It will be necessary to increase the funds for this work.

14. *General Health of the Station.*—The general health of the station during the year under report was good. Relief was afforded to 9,081 new cases, of which 8,913 were treated in the out-patients department, and 168 admitted as indoor patients an increase of 1,424 cases over last year's total. The increase in attendance was due to the great prevalence of malarial fevers and cholera in the surrounding villages.

Two hundred and ninety-nine cases amongst European officers and families were attended to, an increase of a hundred and fifty-three over last year's total.

The daily average number of patients treated was 7·59 indoor and 53·6 outdoor against 7·87 and 49·05 respectively during the previous twelve months.

Five deaths occurred in hospital—

Two from cholera.
One from malarial cachexia.
One from dysentery.
One from phthisis and pneumonia.

Nine cases of cholera occurred among the families of the Indian staff during the months of May and June 1912 with two deaths. Immediate and successful measures were taken to prevent the disease spreading in Pusa, including the thorough cleansing and disinfection of all the wells in the Estate.

One hundred and twenty-one surgical operations were performed, of which twenty-five were major and ninety-six minor operations.

Quinine was issued prophylactically on the Estate, towards the close of the monsoon.

Twenty-four primary vaccinations and eight revaccinations were performed in the early part of the year.

15. *Accounts.*—The total expenditure during the financial year 1911-12 was Rs. 3,04,045, as under :—

	Rs.
Agricultural Research Institute, Pusa—	
Office of the Director	69,015
Chemical Section	41,012
Mycological Section	19,622
Entomological Section	37,345
Pathological Entomological Section .	24,188
Botanical Section	41,542
Bacteriological Section	22,108
Agricultural Section	49,213
TOTAL .	3,04,045

16. *Visitors.*—Visitors to Pusa between 1st July 1911 to 30th June 1912, numbered among others :—

The Hon'ble Mr. Syed Ali Imam, C.S.I., Bar.-at-Law, Member in charge of the Legislative Department, Government of India.

Mr. Abdul Aziz, Bar.-at-Law, Peshawar.

Mr. C. V. Piper of the United States Department of Agriculture, America.

The Hon'ble Sir R. W. Carlyle, K.C.S.I., C.I.E., I.C.S., Member in charge of the Department of Revenue and Agriculture, Government of India.

The Hon'ble Mr. W. H. Clark, C.S.I., C.M.G., Member in charge of the Department of Commerce and Industry, Government of India.

Mr. R. Nagamine, Director of the Government Stock Farm in Formosa.

Mr. T. Kawakami, Director of the Government Museum, Formosa.

Lieutenant-Colonel C. Norie, Dehra Dun.

Mr. D. Quinlan, M.R.C.V.S., Superintendent, Civil Veterinary Department, Bengal.

The Hon'ble Surgeon-General Sir C. P. Lukis, M.D., F.R.C.S., K.C.S.I., Director General, Indian Medical Service.

The Hon'ble Mr. R. C. C. Carr, I.C.S., Officer on Special Duty in the Board of Revenue, Madras.

Mr. A. E. Andrews, Entomologist to the Indian Tea Association.

Dr. A. D. Imms, Forest Zoologist.

Dr. H. Morstatt, Entomologist at Amani, German East Africa.

Munshi Akhtar Mohammad Khan, Deputy Collector in the United Provinces.

REPORT OF THE IMPERIAL AGRICULTURIST.

(S. MILLIGAN, M.A., B.Sc.)

1. *Charge and Establishment.*—The Pusa Farm and Experimental Station continued under the charge of Mr. Dobbs, Assistant Inspector General of Agriculture in India, till April 28th, 1912, when he proceeded on leave. I joined my appointment as Imperial Agriculturist on May 8th.

Mr. H. Southern, B.A., Supernumerary Agriculturist, who had been officiating Deputy Director of Agriculture, Madras, was transferred to the Punjab in April last, to take up a similar appointment there.

Mr. Ganpatlal Dayashanker Mehta, L.Ag., B.A., N.D.A., N.D.D., late of the Bombay Agricultural Department, was appointed Supernumerary Agriculturist on 4th June, 1911, and has been on deputation under the Bombay Government at Poona.

Mr. Judah Hyam, Veterinary Overseer, continued in charge of the breeding herds. He obtained three months' leave from July to October during which period Mr. L. S. Joseph officiated for him.

Messrs. Md. Ikramuddin and Md. Ziauddin Hyder held the appointments of Farm Overseers throughout the year. Mr. Ikramuddin arranged the camps of the Board of Agriculture and of the Tirhut Agricultural Show at Pusa, and his services in this connection were acknowledged by both bodies.

Mr. Nizamuddin Hyder of the staff of the Inspector General of Agriculture had charge of the poultry-breeding experiments until 26th October 1911, when he reverted to his original post on the staff of the Fibre Expert to the Government of Eastern Bengal and Assam. Mr. Ali Murtaza, Fieldman, was appointed in his place.

2. *Training.*—Mr. M. Fatehuddin, B.A., Assistant Director of Agriculture, Punjab, completed his two years' course of training in general agriculture on 21st August, 1911, and returned to the Punjab.

Three students attended the short courses on Cattle-breeding and Poultry management.

3. *Character of the Season.*—The rainfall during the year amounted to 56·30″. The monsoon arrived early and gave copious rainfall throughout its duration. Three severe floods damaged the kharif crops considerably and a late flood retarded the sowings of the rabi crop. The oat crop sustained some damage through late winter rains.

4. *Cropping.*—The following is a list of crops grown :— barley, oats, wheat, castor, bhindi, sugar-cane, jute, rice, maize, arhar (*Cajanus indicus*). Other crops grown on small plots for the Entomological Section included a number of millets and pulses.

5. *Cattle-breeding Herd.*—The numbers of the breeding herd are as follows :—

Cows 74, Bulls 5, Young stock 118

against „ 69, „ 3, „ „ 105 in 1911

Eleven cows, one bull and 19 young cattle have been sold during the year.

An outbreak of Foot and Mouth Disease in August 1911 caused the death of nine of the young stock. There was, however, no mortality in the milking herd from this cause. Three cases (all fatal) of black quarter occurred in June of this year. The Veterinary Overseer is to be congratulated on the prompt and successful measures undertaken to prevent an epidemic of this disease. The local Veterinary Department rendered valuable assistance in preventive inoculation.

6. *Sheep.*—The Gorakhpur sheep continue to do well. Dumbha rams are still used for crossing. The progeny will be used as a basis for the further improvement of wool production.

7. *Pastures.*—As indicated in last year's report a 4-acre plot was laid down to permanent pasture after a green manure.

8. *Clearing and Levelling.*—Roads have been constructed in the low-lying brick-field area and a portion of the waste land reclaimed.

9. *Fodder.*—The economic value of guinea grass as a fodder has been established and returns up to 350 maunds per acre obtained.

10. *Implements and Machinery.*—The wheat and oat crops were mostly cut by machines. The futility of a short cutting bar was demonstrated by the average daily work of two machines, *viz.*:—

A.	4½ ft. cut . . .	5½ acres per day.
B.	3 „ . . .	3 „ „

The general cultivation has been much improved by the use of light ploughs of the Rajah and Punjab types which suit local conditions.

Spring toothed harrows have been found useful in preparing land for crops and maintaining summer fallows.

11. *Experiments.*—The following experiments are in progress and will be continued—

(*1*) The permanent manurial and rotation experiments started in 1908.

(*2*) The improvement of the sugar-cane crop by trenching, earthing up and intertillage.

(*3*) Experiments with regard to the sprouting of sugar-cane sets. A promising start was made last year by steeping the sets in water at 100° F.

(*4*) The application of crude sulphate of soda to paddy. An increase of 17 maunds of grain per acre on a 5-acre experiment was obtained last year. This preliminary result requires confirmation as information regarding the uniformity of the plots treated was not complete.

12. *Poultry.*—The following 5 out of 31 breeds imported and put under trial have been selected as suitable for the country and for crossing purposes :—

(1) Buff Orpington.
(2) White Wyandotte.
(3) Chittagong.
(4) Lakha Game.
(5) Mammoth Bronze Turkeys.

Owing to the rejection of unsuitable breeds, the general condition of the birds has shown a great improvement on previous years.

13. Programme of work for 1912-13.

In addition to the permanent experiments recorded above the following will be undertaken :—

General.—The organization of the estate work has been recently altered and the fieldmen now hold charge of independent sections. It is hoped that a more intimate acquaintance with the varying soil conditions will be made possible.

The large low-lying brick-field area will be further subdivided by roads. A good deal of levelling remains to be done before much detailed field experimenting can be undertaken, but this work will be pushed on as rapidly as possible.

Cropping.—A great improvement has been made in the general cultivation by the adoption of regular rotations. A special study of the maintenance of the fertility of the soil under the rotation and system of manuring adopted will be made. This system includes a dressing of superphosphate applied directly to a green manure. Quantitative estimates of the artificial manures necessary and the period of application will be made.

Field experiments have been started in collaboration with the Imperial Agricultural Bacteriologist to gain in-

formation regarding the decomposition of green manures under varying conditions of—

(*a*) Water content of the soil,
(*b*) Air content of the soil,
(*c*) Age of plant at time of burying,
(*d*) Depth of burying,

and as to the effect of such manures on the condition of the soil.

Cultivation.—Special investigations as to the value of intertillage by bullock implements in maize and sugar-cane will be undertaken. Correct spacings for maize both as a fodder and grain crop will be studied.

An improvement in the methods of working the heavier low-lying land appears to be necessary and improved implements will be given a trial.

Breeding Herd.—The present Montgomery herd is doing satisfactorily, although the milk yield is not as high as might be desired. Owing to the demand for milk from the subordinate staff and the want of budget provision for extensive purchases a rigid selection of the best milking cows has not been possible. This tends to keep down the average yields. Line breeding will be necessary as pedigree cattle of this breed are not obtainable in the country.

Sheep.—The young Gorakhpur Dumbha cross ewes will be used as a foundation for further improvements in wool production. It seems necessary to investigate what type of fleece is the most suitable for sheep in the plains of Northern India, whether a loose coat with a good length of staple or a close fine coat. It is also necessary to regularize and limit the lambing period, to cast the ewes at regular ages, and to employ a more rigid selection as regards wool.

Pastures.—A study of the agricultural characters of pasture grasses and legumes will be undertaken with a view to the sowing of mixtures instead of pure cultures of *dubh*. The effect of rolling, harrowing and topping pastures will

be noted. The rough river-side grazing areas will be systematically cut and grazed with the object of their ultimate improvement. The question of the cheapening of the present methods of laying out of land to pasture will be taken up.

REPORT OF THE IMPERIAL AGRICULTURAL CHEMIST.

(J. Walter Leather, Ph.D., F.I.C., F.C.S.)

1. *Charge and Establishment.*—This section was in the charge of myself during the whole year.

Mr. H. E. Annett, Supernumerary Agricultural Chemist, returned to duty at Pusa on 6th November 1911 from Cawnpore, where he had been acting as Principal of the Agricultural College. He left Pusa again on May 9th, 1912, to act as Agricultural Chemist, Punjab.

Mr. Bhailal Motibhai Amin has continued on deputation at the Sirseah Indigo Research Station. Babus Narain Lal Tewari and Narendra Nath Mitra, M.Sc. (All.), are the two new assistants, who have been appointed to fill vacancies which had occurred.

2. *Meteorology.*—In addition to the usual meteorological observations which are submitted to the Meteorological Department monthly, records are maintained of (*i*) pressure by means of a barograph, (*ii*) soil temperatures at depths of 1 in. down to 2 ft. from the land surface by means of maximum and minimum thermometers, and (*iii*) evaporation from a plain water surface.

3. *Drainage Data.*—The amount of water which drains annually from fallow land and from land bearing crops is determined at Pusa and at Cawnpore by means of gauges, descriptions of which have been published.* The water is analysed regularly in regard to certain constituents, such as nitrogen compounds and mineral matters. The records of the first few years have been published as a Memoir† of this Department. The chief deductions admissible from these records were detailed in my last annual report.

* Annual Report of Cawnpore Farm, 1905-06, page 23, and Memoir of the Department of Agriculture in India, Chemical Series, Vol. I, No. 5.

† Memoir of the Department of Agriculture in India, Chemical Series, Vol. II, No. 2.

Among the observations made was that not only was there less nitrate in the drainage water from the cropped soil than from the fallow land, but that the deficiency could not be accounted for merely by assimilation by the crop. Either less nitrate was formed in the presence of the crop or some other agent than the crop was assimilating the nitrate. The crops had been wheat and maize at Pusa. In order to test if a like result is obtainable when other crops are grown, the maize has been replaced by sunn hemp; and wheat is grown in rotation on one gauge only. In this manner it is hoped to ascertain whether there is a deficiency of nitrate in the drainage water from this system of cropping as there was from the wheat-maize.

Reference was also made in my last report to estimations of nitrate in fallow land throughout the season. These were continued last monsoon and cold weather and will be repeated during the coming cold weather.

4. *The Water Requirements of Crops.*—Work was continued on this subject during last cold weather, more especially with reference to the transpiration ratio of crops grown in the Cawnpore soil. This soil had not been employed previously in the pot-culture experiments at Pusa and also the field experiments at Cawnpore had been interfered with by bad seasons. The pot-cultures yielded ratios very similar to what had been obtained in other soils. The field plots yielded results which differed from those at Pusa chiefly in the fact that the soil moisture was drawn upon by the plant from a greater depth than was the case at Pusa.

5. *Soils. Usar.*—The nature of the work on *usar* soil in the United Provinces has been indicated in previous reports, and especially in my last year's report. The examination of the soils taken from alkali spots in the Muttra and Etah Districts left no doubt that these alkali spots are identical in character whether they occur under well or under canal irrigation. The experiments which have been in progress at Pusa on some soil which was taken originally

from good land closely contiguous to alkali land, and which were designed to demonstrate whether such soil would become *usar* if maintained in a water-logged state, have not so far yielded a definite answer. Both soils were examined after being under experiment for two years, and one was apparently still quite good; in respect of the other there was a doubt as to whether it had changed somewhat.

The whole series of tests were reported upon to the Director of Land Records and Agriculture and to the Chief Engineer, Irrigation Branch, United Provinces.

A series of samples of soil from Quetta were submitted to me for examination by the Irrigation Officer in Baluchistan, the question being whether irrigation was causing the lands to become saline. It was known from analyses made by me in 1909 how very saline the water of the Sheboo canal frequently is, and there is a natural suspicion that irrigation with it must lead to an accumulation of salts in the soil. The examination of the soils showed that in three cases out of four the irrigated land was less readily permeable to water than the unirrigated, and in two cases the irrigated land contained rather more salts. The difficulty in making a reliable deduction in questions such as this lies in the fact that the changes which may be going on are only slow and hence frequently difficult to detect.

6. *Saltpetre.*—Further experiments were made during the year on an improved method for refining crude saltpetre. The filter, which had worked very well at the Allahabad Exhibition, proved, when made of a considerably larger size, to be defective, and experiments are now being conducted with another class of filter which it is hoped will be more efficient. The refined saltpetre was sold in Calcutta without any difficulty at full market rates.

7. *Sugar.*—Work on sugar during the past year has included (*i*) an examination of the date sugar industry, (*ii*) testing the effect of removal of cobs from maize which results in an accumulation of sugar in the stem, (*iii*) estimating the error which is involved in sampling sugar-cane,

and (*iv*) an examination of sugar beet roots which were grown near Peshawar.

8. *The Date Palm Sugar Industry.*—As mentioned in my last annual report, an investigation of the date palm sugar industry was commenced at my suggestion by Mr. Annett during the cold weather of 1910-11. This was continued during the cold weather of 1911-12 and has resulted in an accumulation of some very valuable information on the subject. In addition to a review of its past history, Mr. Annett has been able, by spending some months in the Jessore District, to obtain an intimate knowledge of the present conditions of the industry, its agriculture, mode of cultivation, tapping, and manufacture of the raw and refined sugars. Also he conducted a long series of tests in camp in Jessore on the quantity and composition of the juice, the amount of decomposition and the means by which this might be prevented. Mr. Annett found that the fresh juice contains 8 to 10 per cent. of sucrose associated with practically no glucose, but that owing to imperfect methods of collection, 1 to 2 per cent. of glucose is formed during the night. There are also subsequently further losses of sugar during the boiling process, which is at present carried out in small earthen pots, and again during the native refining processes losses of sugar occur. In an account of this work, which is to be published, Mr. Annett refers to the great improvements which have been introduced into the corresponding American industry—the maple sugar manufacture—in which case it is to be noted that a juice containing only some 3 per cent. of sugar forms the "raw material." If one can afford to employ good appliances and perfected methods in that industry, it should certainly be possible to apply them to India's date sugar.

The reference to this investigation would be incomplete without an acknowledgment to Mr. E. G. McLeod of Kotechandpur, who rendered Mr. Annett very considerable assistance and provided him with detailed information of the profits and losses of his (Mr. McLeod's) factory.

9. *De-cobbing Maize Plants.*—Several Agricultural Journals* have contained notes on the effect of removing the cobs from maize plants prior to fertilisation by the pollen. this process being said to result in an accumulation of sugar in the stem. Experiments were made by Mr. A. C. Dobbs, Assistant Inspector General of Agriculture, during last monsoon period in order to test the effect of the process and to ascertain whether it would prove itself a useful one. Analyses of the plants showed that an increase of sugar (sucrose) did occur; in one case the cane sugar rose from 2 per cent. to 9 per cent., the percentage referring to the weight of stem, but the process was not considered on the whole to be an economical one.

10. *Experimental Error in Sampling Sugar-cane.*—It will be readily appreciated that when a sample of cane is taken from a field which is supposed to represent the whole, an error is involved, and the examination of the sample will not show the average composition of the whole but will depart from the true value to a greater or less degree. It is also obvious that not only is a knowledge of the magnitude of this error of importance, but also that it is very desirable to know how to take a sample of sugar-cane in order to free the result of such errors as far as possible.

Some tests were made in 1910 and again this year with the sugar-cane crop which were designed to elucidate the subject, but it will be necessary to carry out a third series of tests during the coming season in order to arrive at definite conclusions. In illustration it may be mentioned that if a sample of 3 or 6 canes is taken from a field the "probable error" is about 1 per cent. to 2 per cent. in the sucrose determination. By taking more and more canes in the "sample" the error becomes naturally smaller, but even if one-fourth of the crop of a $\frac{1}{10}$-acre plot be crushed, an appreciable error still remains, and one-fourth of such a crop is a large quantity of cane. It is the size of the smallest necessary sample to be taken in order to secure an

* Agricultural Journal of the Union of South Africa, Vol. I, No. 4, p. 540. Agricultural News, Vol. X, No. 234, p. 115.

error less than a certain magnitude that we desire to estimate.

11. *Sugar Beet Roots.*—Some samples of sugar beets which had been grown near Peshawar by the Superintendent of Farms were examined and the result is of interest because one lot included beets of a high grade. The percentage of sucrose varied in this lot between 17 per cent. and 20 per cent. of sucrose in the juice, demonstrating that very good sugar beet could be grown in Northern India if desired.

12. *Milk.*—In co-operation with Mr. A. C. Dobbs a series of tests were made during the year on the quantity and composition of the milk of the Montgomery herd at Pusa which have led to some interesting results. The work will not be completed until next year, but the following will indicate its nature.

When testing cows' milk in India two sources of error must be guarded against : (*i*) if the periods between milking are not equal the composition of the milk will be influenced, and (*ii*) the calf takes an indefinite quantity of the milk unless this is specially controlled. In order to eliminate these sources of error the cows were milked at 12 hour intervals, and the calf allowed to take the whole of the milk from only one side of the udder, the other half being milked by hand. The cows were milked by hand for 24 hours on (say) the right hand side of the udder whilst the calf took the milk from the left hand side, and then during the succeeding 24 hours the left side would be hand-milked, whilst the calf took milk from the right side. Moreover the diurnal change from the right hand side to the left hand side was made in the morning for one month, and in the evening during the next month. During one period of two months the milk of the fore and hind quarters of the udder of three cows was separately examined.

By these means great regularity was obtained in the composition of the milk and several characteristic differences were observed. The most prominent was the difference between the percentage of fat in the morning and evening milk; the former always contained from ·5 to 1·5 per

cent. more than the latter; the difference was greater with some than with other cows, but no cow was an exception to the rule. No *systematic* difference was found in the composition of the milk of the one side of the udder and the other side, but a *systematic* difference was observed with two cows in the composition of the milk of the fore quarter udder and hind quarter respectively. This latter point was tested with only three cows, so that whether this is a common or an exceptional characteristic of the cows is not yet known. The percentage of fat in the milk of this herd has been about 4 to 5 per cent. in the morning and 3 to 4 per cent. in the evening, which is less than has been found for Sind and Gir cows at Poona.

Regarding the *yield* of milk this was found to be from 5 to 6 lbs. per day *obtained by hand*, to which must be added the like quantity taken by the calf, making 10 to 12 lbs. or say 5 to 6 seers daily which is also less than what the Sind and Gir cows yield.

13. *Education.*—There are at present five students in this section; three of these being Government stipendiary students, one each from Bengal, Bihar and Orissa and Travancore; and two private students. One of the students mentioned in my last report was considered not likely to prove himself an efficient assistant and he was consequently not permitted to complete his full course of study. One student of the Entomological Section took a special course of photography.

14. Programme of work for 1912-13.

1. The work on the availability of plant food in soils will be continued.

2. In the current work on the moisture requirements of crops, the effect of different proportions of moisture in various soils for various crops is being ascertained.

3. The investigation of the chemistry and manufacture of date palm sugar will be continued.

4. Experiments on possible improvements in the manufacture of saltpetre will be continued.

5. The experimental error in sampling sugar-cane is being ascertained.

6. The effect of certain factors, such as climatic changes, time of milking, etc.. on the composition of cow's milk, is being investigated.

7. *Education.*—This requires no special comment and will be conducted according to the lines laid down.

16. Publications.

The following papers have been published :—

1. "*Records of Drainage in India.*"—Memoir of the Department of Agriculture in India, Chemical Series, Vol. II, No. 2, January 1912.
2. "*Flow of Water and Air through Soils.*"—Journal of Agricultural Science, Vol. IV, Part 3.
3. *The effect of* (i) *alkali and* (ii) *impermeability in soils on plant growth.*—(VIII International Congress of Applied Chemistry.)
4. *Method for the determination of the rate of percolation of water through soils.*—(VIII International Congress of Applied Chemistry.)
5. *Report on Industrial and Agricultural Chemistry* for the Board of Scientific Advice (by Messrs. Leather, Hooper and Puran Singh).
6. *Date Palm Sugar.*—Memoir of the Department of Agriculture in India (*in the press*).

REPORT OF THE IMPERIAL ECONOMIC BOTANIST.

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

Part I.

Teaching, Training and Staff.

Charge.—I held charge of the section at Pusa during the period under review, namely, the year ending June 30th, 1912.

Students.—One advanced student from the Agricultural Department of the Central Provinces worked in the section from October 1st, 1911 to the end of April 1912. This student made considerable progress in spite of his want of familiarity with growing crops.

Staff.—The appointment of a Personal Assistant has very materially facilitated the working of the section and, at the same time, has greatly increased the volume of results obtained. During the months July to September 1911 and during May and June of 1912, when I was at Quetta, the Second Assistant, Moulvi Abdur Rahman Khan, was in charge of current work at Pusa and I have pleasure in reporting that he carried out his duties in a very satisfactory manner. The monsoon season of 1911 was a difficult one due to the excessive rainfall, but in spite of this the tobacco crop was good and the rest of the land in the botanical area compared favourably with anything I saw in the neighbourhood on my return to Pusa at the end of September. The work of the rest of the staff was satisfactory.

Part II.

Wheat Investigations.

The wheat investigations at Pusa have been extended during the past year and results of considerable value have been obtained.

Trials of Pusa Wheats in India.

During the *rabi* season of 1911-12 extensive trials of wheats were made in most of the important wheat tracts of India. As these trials have, in many cases, passed the experimental stage and the wheats are being grown on a large scale for seed distribution, the present seems a fitting opportunity of summing up the results so far obtained and of giving a connected idea of this portion of the wheat investigations.

One of the first results of the wheat investigations at Pusa was the demonstration of the fact that varieties with milling and baking qualities similar to those of the best wheats on the English market could be grown to perfection in Bihar under *barani* conditions. By the application of modern methods of selection and hybridization these high grain qualities were successfully combined with high yielding power, rust-resistance and strong straw so that wheats were produced which gave upwards of 2,500 lbs. of grain to the acre without irrigation or manure. In one case, a yield of 2,832 lbs. to the acre was obtained at Pusa. These new wheats were then thoroughly tested in England, both in the mill and bakehouse, and were found to behave like Manitoba spring wheats, which are in greatest demand for bread-making in England and which command the highest prices on the Home markets. In this portion of the work I was fortunate enough to secure the co-operation of Mr. A. E. Humphries, a past President of the Incorporated Society of British and Irish Millers.

The next stage in these investigations was to extend the trials to other wheat-growing areas in India. These were carried out during the *rabi* seasons of 1910-11 and 1911-12 and the results are summed up below.

United Provinces.—As most of the wheat exported from India is grown under irrigation, it was important to ascertain by actual trials whether high grain quality and high yield could also be obtained under canal irrigation. Fortunately in this portion of the investigations the active co-operation of Mr. H. Martin Leake (Economic Botanist

to the Government of the United Provinces) was secured and extended trials of the Pusa wheats have been carried out during the past three years at Cawnpore. The results obtained were most satisfactory. In the first place, it was found that yields over 2,200 lbs. per acre and in one case as high as 2,500 lbs. could be obtained with one watering, that is, with one-third the water usually employed by the cultivators in the neighbourhood. In the second place, the appearance and milling and baking qualities of the wheats were at least equal to those grown at Pusa under *barani* conditions. This was the verdict of Mr. Humphries, who, in 1911, tested the same kinds grown at Cawnpore under canal irrigation and at Pusa as a dry crop. During the last *rabi* season, one of the Pusa wheats was grown at Cawnpore without any irrigation water at all and a yield of 1,650 lbs. to the acre was obtained, a remarkable result in a canal-irrigated tract.

The Cawnpore trials, which had extended over three seasons and which were uniformly successful, were repeated on a small scale on the Aligarh Farm in 1910-11 and again in 1911-12 on a large scale by Dr. Parr, Deputy Director of Agriculture. The yields obtained during the last season are given in the table below.

Trial of Pusa wheat at Aligarh, 1911-12.

Name.	Yield in lbs. per acre.
Pusa 22	2,098
Pusa 8	2,139
Pusa 12	2,510

During the last *rabi* season the Pusa wheats have been grown on a considerable scale by the tenants of the Court

of Wards Estates in the District of Kheri. The following are some of the results obtained by these cultivators :—

Results of the Pusa wheats grown by ryots under the Court of Wards Estate, Kheri.

Name of wheat.	Name of estate or circle.	Previous treatment of land.	Yield per acre in lbs.
Pusa 12 .	Kaimalua . .	Unmanured .	2,222
Pusa 12 .	Rajapore . .	Ditto . .	1,619
Pusa 101 .	Mankapore . .	Ditto . .	2,057
	Bhulanpore . .	Ditto . .	1,935
	Amirtaganj . .	Manured . .	1,285
	Rasulpanah . .	Ditto . .	1,563
	Tendhua . .	Ditto . .	1,234

It will be seen that in the United Provinces the trials have extended over three years at Cawnpore and two years at Aligarh and the wheats have also been grown by cultivators. In all cases they have been successful.

Punjab.—At the Gurdaspur Experiment Station in the Punjab during the past wheat season, the following results were obtained under strict *barani* conditions on unmanured land by Mr. Milligan, the Deputy Director of Agriculture. These results are the immediate outcome of the application of improved methods of wheat growing to the *barani* tracts of the Punjab.

No.	Grain in lbs. per acre.	Bhusa in lbs. per acre.
Pusa 12 . .	2,122	3,989

On the canal-irrigated tracts of this Province the methods of growing the crop to perfection, which have

proved so successful at Cawnpore and Aligarh, have not yet been worked out. One point, however, has been demonstrated. In 1911, it was found that high quality Pusa wheats grown by tenants of the Lyallpur Farm retained their milling and baking qualities. There is every hope that provided proper care is taken in cultivation and in the use of irrigation water, results similar to those of Cawnpore can be obtained in the Canal Colonies of this Province.

Central Provinces.—As the soil conditions of the wheat-growing tracts of Peninsular India are quite different from those of the alluvium of the Indo-Gangetic plain it appeared probable that the Pusa wheats, most likely to be suitable for the black soils of the Central Provinces, would be found among the rapidly maturing varieties. Accordingly, these have been tested at Tharsa and Raipur by Mr. Clouston and one kind was tried on a small scale at Hoshangabad this year by Mr. Evans. The results are given below.

Trial of Pusa wheats, 1911-12, in the Central Provinces.

Name.	Yield per acre.	Remarks.
Pusa 12 . .	885	
Pusa 107 .	769	
Pusa 108 . .	750	
Pusa 4 . .	645	Damaged by hail.

The yield of the local kinds in the Central Provinces rarely exceeds 600 lbs. per acre and both at Tharsa and Raipur the Pusa wheats gave a larger outturn than any of the other varieties tried, while in rust resistance and grain quality they proved distinctly superior.

As regards the quality of the Pusa wheats grown in the Central Provinces, one, Pusa 4, was in 1911 tested in England by Mr. Humphries who reported: "The Raipur unirrigated lot is truly superb in appearance, indeed I do

not think I am exaggerating if I say it is the finest looking lot of Indian wheat I have ever seen." As regards the bread made from this wheat Mr. Humphries said : " In hue and general appearance of crust and crumb the Raipur lots are of the very highest class, but on the one point of strength they are really good without being extraordinary, judged by the standard of typical London flour." These opinions were confirmed by Messrs. Ralli Brothers, who valued Pusa 4 higher than any of the large collection of Indian wheats grown at Raipur in 1911. It is probable that this wheat will be of the greatest use in the Central Provinces on light soils and in years when the soil moisture is short as it ripens in the second half of February and fully a month before the local wheats. Next year it is being tried by Mr. Evans in the Jubbulpore District where a rapidly maturing late sown wheat is required on the embanked wheat lands.

Bihar.—The first trial of Pusa wheats in Bihar was made at Mia Chapra Estate in 1909-10 when 1,975 lbs. to the acre of Pusa 20 were obtained after maize the same year. All the seed was sown the following year on this estate and the resulting crop was disposed of at Rs. 5 per maund as seed wheat.

In 1910-11, several other estates grew Pusa wheats on a small scale and in all cases the yield was greatly in excess of that given by country seed. The success of these trials on a small scale led to a great demand for seed after the harvest of 1911.

During the past season, the trials were considerably extended and about 1,500 acres of land were sown with the new wheats. Some of the results are to be found in the following table and on the average the yields obtained are at least twice that given by the local wheats. The growers are very pleased with the results and are keeping the bulk of their harvest to sow an extended area next year. It is anticipated that between 10,000 and 15,000 acres will be sown with Pusa wheats next year.

Trial of Pusa wheats in Bihar in 1911-12.

Name of wheat.	Name of Factory.	Type of soil.	Yield per acre in lbs.	Remarks.
Pusa 20 .	Bowarrah Concern .	1st class wheat land.	1,975	
	Ditto .	2nd class wheat land.	1,483	
	Mia Chapra Concern, 1909-10.	1st class wheat land.	1,975	
	Mia Chapra Concern, 1911-12.	Do.	2,468	
	Belsund Concern .	Medium .	1,619	
	Bowarrah Concern .	Fairly heavy	1,240	
Pusa 6 .	Motihari Concern .	Light loam .	1,839	
	Belsund Concern .	Medium .	1,730	
Pusa 8 .	Hathowri Concern .	1st class wheat land.	2,017	
	Munjhoul Concern .	Light .	1,218	The Manager states that the soil was too light for wheat.
Pusa 12 .	Mooktapore Concern	Medium .	1,481	Patna wheat sown in the same field gave only 1,028 lbs.
	Rewari Concern, 1910-11.	Land seethed	1,199	Late sowing affected the yield.
	Bogwanpore Concern	Light . .	1,234	Badly attacked by white-ants.
Pusa 8 and 12 mixed.	Motihari Concern .	Light loam .	1,693	Yield affected by laying due to storms.
Pusa 101 .	Bogwanpore Concern	Light . .	1,234	Badly attacked by white-ants.
	Jugolia Concern .	*Matar* green manured.	1,351	Wheat laid and consequently yield affected by over-manuring.

Trials of Pusa wheats in Bihar in 1911-12 —contd.

Name of wheat.	Name of Factory.	Type of soil.	Yield per acre in lbs.	Remarks.
Pusa 104 .	Belsund Concern .	Poor . .	1,451	The Manager estimates the yield would have equalled Pusa 105 if land had been good.
Pusa 105 .	Belsund Concern .	..	1,798	
Pusa 106 .	Hathowri Concern .	1st class wheat land.	1,880	Damaged by rain and rats or yield would have been still greater.
	Birowlie Concern .	2nd class wheat land.	1,707	
	Motihari Concern .	Light loam .	1,460	
	Dholi Concern .	Light land somewhat poor.	1,174	Local wheat in adjoining field gave less than half this yield.
	Mia Chapra Concern	Medium .	1,645	
	Bogwanpore Concern	Light . .	1,234	Crop badly attacked by white-ants.
	Mooktapore Concern	Medium .	1,480	Damaged by water-logging; local wheat gave two-thirds this yield in the same field.
	Belsund Concern .	Light .	1,139	Sown on soil too light for this wheat.

All the land was unmanured unless otherwise stated.

Owing to the abnormally heavy and late "hathia" rains in 1911-12 most of the wheat in Bihar had to be sown on light or second class wheat lands as the first class wheat lands did not dry in time to plough. Much of the wheat was also sown on a wet seed bed. The yield of wheat this year at Pusa, owing to the late October rains, averaged

1,600 to 2,000 lbs. an acre instead of the usual 2,000 to 2,500 lbs.

Cultivation Experiments.—Another aspect of the wheat investigations at Pusa should be mentioned. This relates to the importance of hot-weather cultivation, clean culture and moisture conservation in crop production in the Indo-Gangetic plain. By applying the methods of cultivation, which have been found successful for wheat, to other crops, both *kharif* and *rabi*, greatly increased crops are easily possible. The Pusa results have already attracted great attention in India to improved methods of cultivation and moisture conservation and have thus been of direct use in showing one of the directions in which the land, now under crops in the plains, can be made to produce much heavier outturns. The effect of these methods is cumulative and the highest yields are not obtained till the second or the third year. The methods of cultivation referred to have been published in detail in Pusa Bulletin No. 22 and Urdu and Hindi versions have also been issued. Of these latter a second edition has been called for by Mr. Burt, Deputy Director of Agriculture, for distribution in the Central Circle of the United Provinces.

Seed Distribution.

As a result of the successful trials of the new wheats in various parts of India a great demand for seed has arisen during the past year which could only in part be met. Arrangements, however, have been made to grow a large stock of seed during the coming season which it is hoped will be sufficient for all purposes.

The seed distribution arrangements in Bihar arose out of the demonstration in wheat growing given in connection with the Tirhut Agricultural Exhibition held at Pusa in January last. After this show the Bihar Planters' Association suggested the immediate formation of seed farms on estates under my supervision so as to supply a large amount of seed wheat yearly. This has been done and about 1,000 acres of the new wheats will be sown on

three estates next year for seed purposes. This arrangement ensures the expansion of the work at practically no cost to Government while the estates where the crop is grown to perfection will also serve as demonstration areas and local seed farms for the cultivators in the neighbourhood. The various wheats grown will be maintained at Pusa in pure culture and whenever necessary the seed farms will be re-stocked with fresh seed.

In the United Provinces the distribution of seed is being carried out under the direction of Mr. Leake who has arranged to grow about one hundred acres at Cawnpore and Aligarh.

In the Central Provinces the work of seed distribution is in the hands of Mr. Clouston, the Deputy Director of Agriculture, who is growing Pusa wheats on a large scale at Raipur and Tharsa. Mr. Evans proposes to try one of the early maturing wheats (No. 4) in the Jubbulpore District.

At Pusa, during the past year, the amount of the seed distributed from the botanical area was 250 maunds. In future the chief work at this centre will be confined to keeping the various kinds pure and to growing sufficient seed for demonstration purposes and for re-stocking periodically the various seed farms. In addition, a considerable area of wheat land will be taken up by the numerous cultures in connection with the selection and hybridization work in progress and with variety trials.

The Influence of the Environment on Quality.

An important stage has been reached in the experiments on the influence of environment on the milling and baking qualities of wheat. These investigations are being conducted in collaboration with Mr. Leake and the results obtained up to the *rabi* season of 1910-11 have been incorporated in a paper which is now being printed. The object of these experiments is to discover to what extent high quality in grain is possible in the various wheat-growing tracts of India and for this purpose various pure lines

have been grown at a large number of stations and the produce tested. If wheat of good quality can be grown in any tract this fact is of great importance in the work of improvement as practically all the Indian wheats of commerce are poor in quality.

The principal result obtained during the year is the demonstration of the fact that wheats of good quality can be grown under canal irrigation in the alluvium and also on the black cotton soils of Peninsular India. Quality in wheat in India is not confined to the *barani* crop. Indeed at Cawnpore during the past year the samples produced under canal irrigation were better than the same wheats grown at Pusa. At Raipur, on the black cotton soil, the samples of Pusa 4 were certainly finer than that produced the same year at Pusa. Even when grown after rice and at Lyallpur by poor cultivators the wheats did not lose their milling and baking qualities.

The results with Muzaffarnagar, a soft weak wheat, obtained at the various stations are also of interest. In no case did this wheat show strength although its milling and baking qualities were improved by the cultivation it received at Cawnpore and Pusa.

These experiments also throw considerable light on the relation between yield and quality in wheat. It was found that, in any particular wheat, the conditions which produce the highest yield are those which also produce the best quality. Further, in the same wheat, high yield and high quality can be combined. A cultivator therefore, who wishes to obtain the greatest financial return for his labour, should grow to perfection a wheat which combines high yield and good grain qualities. When this is accomplished, Indian wheats will be second to none in the markets of the world.

In this portion of the work a large number of milling and baking tests were necessary. These were carried out by Mr. Humphries in England and it is fortunate that his invaluable assistance was secured. Dr. Leather kindly

undertook the large number of nitrogen determinations involved in these investigations.

Cultivation Experiments at Pusa.

In connection with the growth of wheat at Pusa several matters connected with the cultivation of the crop have been observed which have since been made the subject of experiment.

The first concerns the continuous growth of wheat without manure. This experiment is being conducted on a plot of typical wheat land, which is heavy in texture and which retains water well. The past season was the fifth year of the experiment and the yield was twenty-six maunds to the acre, an increase on that of previous years. This is the limit of the yielding power, up to the present at Pusa, of the variety grown on this plot and the results show that, after five years' cropping with wheat without manure, the natural fertility of the land is not yet affected. Indeed, the last crop was much too rank and was laid to a considerable extent by wind after coming into ear.

The next cultivation experiment is concerned with the effect of hot weather cultivation as compared with late ploughing after the beginning of the monsoon. This experiment is now in the second year and last season the difference in yield between the two plots was twelve and a half bushels to the acre in favour of early ploughing. In the first year, the difference was only six bushels, due to the fact that both plots started in a high state of cultivation. This result appears to indicate that the effect of hot weather cultivation is cumulative and that the maximum yields are not realised the first year.

Drainage is an important factor in wheat growing in the alluvium and influences both the yield and the quality. On waterlogged areas, the consistency of the sample is generally very mixed and the yield is low. An experiment on this subject at Pusa showed that waterlogging the land during the month of September previous to sowing reduced the crop fifty per cent., that is, to sixteen bushels to the acre. This was shown to be due to a want of available nitrogen,

caused no doubt by a change in the soil flora due to the waterlogging and want of air. A rice land condition seemed to have been set up in which the wheat crop did not thrive. The subject of the importance of drainage was brought to the notice of the Bihar Planters in February last in a paper read before the Association at Mozafferpore.

Breeding.

During the year a considerable amount of attention has been devoted to wheat breeding, particularly with regard to the production of new rust-resistant wheats with high yielding power and strong straw. In connection with these investigations, which have been designed to secure results of immediate practical value, some interesting facts dealing with the inheritance of characters in wheat have been elucidated. A paper on this part of the subject is in course of publication. These results, which at first sight appear to be only of theoretical interest, are in reality of practical value as they show that the gametic constitution of wheats must be known with certainty before they can be used as parents for the production of new types. Further it is desirable that all varieties of crops in India (whose behaviour in breeding is known) should be most carefully preserved at the experiment stations so that they may be immediately available for other workers.

The new experiment station at Quetta was of use in connection with the breeding work at Pusa. The variety trials in 1912 indicated that two crosses on the pure line A 88 were desirable. This could only be seen at harvest time when it was too late to make the crosses. Seed was, however, sent to Quetta in March and the crosses were made in the following June thus saving a whole year in the work

Part III.

OTHER INVESTIGATIONS.

Tobacco.

The progress reported in the previous annual report with regard to this crop has been continued during the past year.

Cultivation.—The successful growth of this crop after a green crop of *san* ploughed in was referred to in last year's report. This method of manuring was repeated on a large scale in 1911-12 and in spite of the bad season a very good crop was produced. The excessive rain at sowing time in August, followed by long continued wet weather till the middle of October, greatly interfered with the preparation for this crop. In consequence, the growth was slow and the period of ripening delayed. Even under these adverse conditions, the crop grown on *san* was superior to any tobacco fields in the neighbourhood.

Curing.—The curing experiments of the previous year were repeated on a large scale, the crop being grown after *san* ploughed in without any other manure. Three types, Nos. 28, 29 and 32, were grown and cured by a modification of the country method, care being taken to use the minimum amount of moisture in the process so as to preserve the yellow colour as much as possible. Type 28 gives a yellow colour combined with good texture and fine leaves and was reported on very favourably in 1910-11. Types 29 and 32 are heavier, coarser kinds with darker colour and large leaves. These were grown for comparison with Type 28. The whole of the crop was sent to the Peninsular Tobacco Company at Monghyr and made into cigarettes. Type 28 again received a very favourable report and the leaves were valued at Rs. 12 to Rs. 14 per maund which is a considerable advance on the local prices. A large quantity of self-fertilized seed of this type was grown for the Company and arrangements have been made on three estates to grow this kind next year. The results obtained with this tobacco show that a suitable leaf for cigarettes can be grown and cured in Bihar by the people and thus the first object of these curing experiments has been achieved. It now remains to get the Pusa results repeated on the indigo estates and to see whether the planters in Bihar are prepared to take the trouble necessary to grow and cure this tobacco. If they do it will then be possible to consider whether or

not fire curing in some simple form in earth-built barns can be undertaken in Bihar with any prospect of success.

Breeding.—Considerable progress was made during the year by the Personal Assistant in the investigations on the inheritance of characters in *Nicotiana tabacum* and in *N. rustica*. The object of this work is to discover the mode of inheritance of the various leaf characters in particular so that new and improved varieties can be produced by hybridization. The results so far obtained are now being submitted for publication.

It is interesting to note that the earlier selection work done on the tobacco crop at Pusa and published in Nos. I and II of the third volume of the Botanical Memoirs has been repeated by the Bureau of Plant Industry of the United States Department of Agriculture and confirmed in all respects. The American results are published in a recent issue of the *Botanical Gazette* (Vol. LIII, No. 2, 1912).

Gram.

Some time ago a sample of gram was grown in the botanical area from which a number of pure lines were isolated in connection with the investigations on natural cross-fertilization published in No. IV, Vol. III of the Botanical Memoirs. Some of the more promising of these pure lines were grown in large plots in 1911-12 and the yields were carefully determined. Seven lines were grown and one plot contained local seed for comparison. The yields obtained were very high and the largest crop was nearly thirty-four maunds to the acre while two other lines gave over thirty maunds. Samples of the seed were submitted to Messrs Ralli Brothers, Bombay, for valuation and report. Four of the lines were valued over Rs. 4-8 per cwt. f. o. r. Bombay compared with Rs. 4-2, the price of the ordinary exportable varieties. The line which gave thirty-two and-a-half maunds of seed was valued at Rs. 5-8 per cwt. f. o. r. Bombay—an increase of Re. 1-6 per cwt. above the ordinary seed. These lines will be grown on a larger scale next

season and are also being tried in other parts of India. The results indicate that selection methods can be applied to gram with good prospects of success. As the flowers are self-fertilized in Bihar, it is likely that any improvement can readily be maintained.

Fibres.

The work with fibre plants has been continued, the crops studied being patwa (*Hibiscus cannabinus*), rozelle (*Hibiscus Sabdariffa*), and san (*Crotalaria juncea*).

It was found that one of the types of *H. cannabinus* grown from the seed of unprotected flowers could be freed from all hybrids in the seedling and early vegetative stages and thus could be kept pure by simple rogueing. It is possible that similar methods might be adopted in the case of cotton grown for seed distribution purposes. In the case of *san* progress was made in isolating the various varieties of this crop and a beginning was made in the study of the methods of pollination in this species.

In rozelle a considerable amount of work was done on the inheritance of characters in this crop and in the study of the second generation of the hybrids. The varieties of Indian rozelle are well adapted for the study by students of simple Mendelian phenomena and it was partly on this account that this work was undertaken.

Pollination.

Progress was made during the year in the study of the methods of pollination in the various crops of India and particular attention was devoted to some of the oil-seed crops. As soon as sufficient material has been collected these results will be incorporated in a paper.

Part IV.

THE TIRHUT AGRICULTURAL EXHIBITION.

The Tirhut Agricultural Exhibition was held in the botanical area at Pusa on January 18th, 19th and 20th,

1912, and I acted as local Secretary for the show. In addition to the usual exhibits of agricultural produce, live stock and the products of the local industries, the special feature of this Exhibition was the demonstration to planters, zemindars and cultivators. The nature of these demonstrations will be evident from the following extract from the report on the show :—

"An important departure was made this year in the Exhibition, largely through the efforts of Mr. F. F. Lyall, I.C.S., Collector of Mozafferpore. In 1910, it was suggested by the Imperial Economic Botanist that the Tirhut Exhibition should be held at Pusa once every four years and that the various improvements in Indian agriculture, shown to be possible by the work of the Pusa Institute, should be demonstrated to the planters, zemindars and cultivators of the Division in the form of growing crops of increased yield and value. This suggestion was not accepted for the 1911 show, but it was revived again by Mr. Lyall and adopted by Mr. H. C. Streatfeild, I.C.S., Commissioner of the Division. As a consequence, the Exhibition of 1912 was held at Pusa and the grounds of the Botanical Section were lent for the Exhibition. In the cultivated portion of this area, numerous plots were laid out to illustrate as many as possible of the improved methods of agriculture discovered at Pusa. The crops selected for this purpose were tobacco and wheat and, in addition, there was a further demonstration on two neighbouring plots of land belonging to ryots.

"The main demonstration to planters, which occupied about three hours, took place on the morning of the 19th January when the attendance was upwards of 50. This consisted of a series of short lectures by the Imperial Economic Botanist followed by discussions at the various plots. It was repeated in the afternoon for the benefit of those who arrived too late for the morning work. Leaflets dealing with the main subjects dealt with, were previously prepared and printed and sets of these were distributed. For the benefit of cultivators these demonstrations were given

in the vernacular, both on the 19th and 20th, by Moulvi Abdur Rahman Khan, Second Assistant to the Imperial Economic Botanist, and were largely attended. In addition to these formal demonstrations, the various members of the staff of the Botanical Section explained the work in progress to the cultivators and, in this way, a good deal of useful work was accomplished.

"The scope of the demonstrations can be gathered from the titles of the leaflets prepared for the show which were as follows :—

1. Green manuring with *san* for tobacco.
2. The improvement of wheat cultivation in Bihar.
3. The effect of grass on fruit trees.
4. The value of pure seed in India.
5. The importance of hot-weather cultivation in Bihar.

In addition, several improved implements, suitable for Bihar, were shown at work and various leaflets dealing with these machines were distributed. After seeing the spring-tine harrows at work fifty of these were ordered by the planters.

"These demonstrations were a great success and were followed closely both by the planters and by the cultivators. There is no doubt that this method of bringing home the results of the work of the Agricultural Department is infinitely more effective than publications or the exhibition of collections of seeds and other produce. An acre plot of improved wheat or tobacco for example appeals much more strongly to the agricultural mind than results in print or in the shape of collections of seed."

Part V.

The Development of the Fruit Industry of Baluchistan.

Progress has been made during the year in the work outlined in the last report in connection with the development of the fruit industry of Baluchistan.

A suitable site for the fruit experiment station was selected on the Sariab road about two miles from Quetta and the land was acquired in September 1911 by the Local Government. This was roughly laid out in terraces and plots last year, and, during the present summer, progress has been made in the final levelling of the plots and in making the necessary irrigation arrangements. Two shares in the Sirkhi karez have been purchased and two artesian bores have been laid down while a third is now in progress. These bores are 80, 150 and 250 feet in depth and tap three different water-bearing gravels. The total surface flow is expected to be well over 1,000 gallons per hour and the water will be finally collected in a pucca tank capable of holding four days' discharge. An experiment has also been made of pumping from one of these bores by means of an oil engine when the flow increased from 600 gallons to 4,250 gallons per hour. A well has been sunk which gave water at 22 feet and on this a Persian wheel is being erected. The water supply of the fruit experiment station is now assured and proposals have been submitted for laying down permanent masonry water channels for the main distribution and for carrying the zemindar's water through the area instead of in the present earth channels.

Five quarters for workmen, a cattle shed, two godowns, an implement shed and overseer's quarters were erected in 1911 as well as a building for laboratory and office work. The area has been surrounded by a wall and the road to the laboratory has been made pucca.

A portion of the land was laid out for a nursery and a number of stocks have been raised for budding during the present year. Some of the land was sown in *shaftal* for fodder and green manure.

The old fruit garden in Quetta was handed over on October 1st, 1911, and a beginning was made in getting this into order and in removing old trees. A portion of the area was got ready for *shaftal* and good crops were produced. Another portion was prepared for an experiment

in the growing of tomatoes on improved lines. During the present year, further progress was made on the work of renovation and it is hoped to get at least half of the land ready for a clover crop this autumn. Next year it is proposed to plant this area up in fruit trees.

A considerable amount of work was done in 1911 in working out the best methods of transporting fruit to India. It was found that the cheapest and best packages were those made up with chip and boards imported from Glasgow. Returnable boxes made of venesta wood were found to be impracticable under Indian conditions on account of the frequent overcharges and mistakes made by the Railway Companies in sending the empties back to Quetta. Any one sending returnable fruit boxes on Indian Railways on a large scale would have to keep at least one clerk to check the charges and to file claims. Another difficulty in connection with sending fruit by rail was the numerous thefts on the trains. If a merchant sending fruit from Quetta were to complain every time these thefts occurred, another extra clerk would be required for the correspondence that would be involved.

As a result of last year's experiments non-returnable boxes for the five-seer rate were designed and steps were taken to import a supply of material for these sufficient to meet the demands for 1912 and 1913. In addition, a supply of other boxes for experiments with tomatoes and other fruits was imported.

In carrying out the work at Quetta I have been greatly assisted by Mr. H. R. C. Dobbs, C.I.E., Officiating Revenue Commissioner in Baluchistan, who did a great deal to further the work after my departure in September 1911. Colonel McConaghey, C.I.E., the Political Agent at Quetta, has also rendered valuable assistance, while the work connected with the artesian bores and the pumping experiments was only possible through the ready help given by Colonel Williams, R.E., Secretary to Government in the Public Works Department, and by Colonel Picton,

A.C.R.E., Quetta. Colonel Duke, I.M.S., Residency Surgeon and Chief Medical Officer in Baluchistan, was kind enough to receive and plant out a number of young trees. He has also helped me by giving me the benefit of his local knowledge of fruit growing and of the practices in vogue in Persia.

My third assistant, Munshi Ijaz Husain, worked well at Quetta in the autumn of 1911 when left in charge of the work.

Part VI.

Programme and publications.

Programme of work for 1912-13.

1. *Training.*—The training of advanced students in this section will be continued.

2. *Plant Breeding and Plant Improvement.*—During 1912 the following crops will be studied :—wheat, tobacco, oil-seeds and fibre plants.

(*a*) *Wheat.*—The production of improved and rust-resistant types by selection and hybridization will be continued. The co-operative experiments on the influence of the environment on the milling and baking qualities of Indian wheats, which are being conducted in collaboration with Mr. H. Martin Leake, Economic Botanist to the Government of the United Provinces, will be continued. The botanical survey of the wheats of Baluchistan and the agricultural survey of the wheats of Bengal will be completed.

(*b*) *Tobacco.*—The production of new varieties by selection and hybridization will be continued, as well as the testing and curing of the varieties already isolated. The detailed study of the inheritance of characters in tobacco is being continued by the Personal Assistant.

(*c*) *Oil-seeds.*—The study of the oil-seeds of India will be continued on similar lines to those adopted in the investigations on wheat.

(*d*) *Fibres.*—The isolation and testing of pure races of the fibre plants of India will be continued. The study of the inheritance of characters in these crops is being continued.

(*e*) *Fruit.*—The fruit experiments at Pusa will be continued on the lines laid down in the first Fruit Report. During the months May to September the work connected with the development of the fruit industry of Baluchistan will be continued.

Publications.

The pressure of current duties has again delayed the publication of results and only a few papers could be written during the year. The work of the section, particularly on wheat and tobacco, has increased beyond all expectations during the past two years and it is difficult to find sufficient free time for writing papers and for correspondence.

The following papers were published or written during the year :—

1. Green manuring with *san*. *Agricultural Journal of India*, Vol. VII, Part I, 1912.
2. A suggested improvement in sugar-cane cultivation in the Indo-Gangetic plain. *Agricultural Journal of India*, Vol. VII, Part I, 1912.
3. The improvement of Indian wheat. *Journal of the Bombay Natural History Society*, October 1911.
4. A Hindi and Urdu version of Pusa Bulletin 22 on the production of wheat in India.
5. The Botanical aspect of the improvement of sugar-cane in India. *International Sugar Journal*, 1912.
6. The production and maintenance of pure seed of improved varieties of crops in India (with G. L. C. Howard). *Agricultural Journal of India*, Vol. VII, Part II, 1912.
7. Report on Economic Botany for 1910-11 for the Board of Scientific Advice (with R. S. Hole).

8. Some aspects of the Agricultural Development of Bihar—an address delivered to the Bihar Planters' Association at Mozaffarpore on January 31st, 1912.
9. The influence of environment on the milling and baking qualities of wheat in India, No. 2 (with H. Martin Leake and G. L. C. Howard). *In the press.*

REPORT OF THE IMPERIAL MYCOLOGIST.

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

1. *Charge and Establishment.*—I remained in charge of the section until June 16th, when I proceeded on 20 days' privilege leave, Mr. F. J. F. Shaw officiating. In addition to my own duties, I also held charge of the post of Director of the Agricultural Research Institute, Pusa, until March 31st. Mr. Shaw held the post of Supernumerary Mycologist throughout the year. Mr. J. H. Mitter, Second Assistant, reverted from the Punjab Department of Agriculture on the abolition of the post of Assistant Professor of Mycology at Lyallpur, which he had held since May 1910, on November 24th. He has again joined the Punjab Department to officiate as Assistant Professor of Botany for three months from June 15th. All the staff have worked well.

2. *Training.*—Babu K. C. Banerji, B.A., L.Ag. (Nagpur), was sent for training in Mycology and Entomology by the Bihar and Orissa Department. He attended the section from February 22nd. Lala Bishambar Das, M.Sc., Assistant Professor of Biology, Government College, Lahore, worked in the Laboratory for about six weeks during his college vacation in July and August.

3. *Aid to Provincial Departments.*—A considerable number of parasitic fungi were named for the college collections in the various Provincial Departments, especially for Bombay, Bengal and the Punjab. The manuscript of the mycological portion of a Handbook of the diseases and pests of cultivated plants in Bengal was read through and annotated. Several blocks of original figures suitable for illustrating this book were lent to the Economic Botanist, Bihar and Orissa. Some manuscripts containing results of scientific work by the Assistant Professor of Mycology and the Mycological Assistant, Poona, were read and advice given as to the best means of publishing them.

4. *Plant disease investigations.* (*a*) *Paddy diseases.*—Considerable time has been given to the investigation of a disease of inundated paddy, locally known as *ufra*, in the deltaic districts of Eastern Bengal. The disease is said by the cultivators to have existed for at least a generation, but it appears to have greatly increased in virulence in recent years, and has been under the observation of the Eastern Bengal Department of Agriculture since 1908. It was attributed by different observers to insects, fungi and unsatisfactory soil conditions. A conjoint Entomological and Mycological investigation was undertaken last December, when Mr. Fletcher, Officiating Imperial Entomologist, and myself visited Noakhali District. The result was to exclude insects as the direct cause and to throw suspicion on a worm of the Nematode class, always found living on diseased plants. This worm, a *Tylenchus*, member of a genus whose species are already known to cause several serious diseases of cereals (of which "ear-cockle" in wheat is perhaps the most familiar), is exceedingly minute, practically invisible to the naked eye; it is found in clusters, often containing many individuals, on the surface of diseased parts. The anterior end is provided with a sharp spine and a sucking apparatus, by which the juice of the living cells of the plant is made use of as nourishment. At least two, probably more, complete life cycles occur in a year and, as the female lays a large number of eggs, increase is rapid. On diseased plants the worms are found, in the early stages, occupying small brown patches on the leaves and culm. As the crop approaches maturity larger numbers of worms occur on the peduncle of the ear and just above the next lower node. At these points the stem is deep brown in colour and shrunken to little more than the thickness of a thread. Still later, worms are found within the empty glumes of the lower flowers and the ears generally bear no grain. A frequent condition is the failure of the ear to emerge from its enclosing sheath and to this the name *thor* (or swollen) *ufra* is applied, from the swollen appearance of the head of the plant. In *pucca ufra* the ears

emerge, but are light and bear no grain. In Begumganj Thana of Noakhali District about half the crop was lost last year; several fields were visited which had not been considered worth harvesting. In 1910 it is estimated that the loss in this Thana was 200,000 maunds of grain. Outside Noakhali, the disease is said to occur in Comilla, Chandpur and the neighbourhood of Dacca and is probably more widely distributed than this. The same worm was found in specimens collected in these localities and the symptoms were similar. Elsewhere, from several of the rice-growing tracts of India, reports and specimens of diseases exhibiting points of resemblance to *ufra* have been received, but examination has not, so far, revealed the occurrence of true *ufra* outside Eastern Bengal. Further work is required to ascertain if the worm must be held directly responsible for the disease and, if so, how it can be checked. Experiments in this direction are in progress in collaboration with the Bengal Department.

An unsuccessful attempt was made to trace by field inoculations the life history of the " false " smut of rice caused by *Ustilaginoidea virens*. This is being repeated this year.

(*b*) *Root rot of plants due to Rhizoctonia.*—The soil-dwelling parasite *Rhizoctonia* has been known in Europe as a fungus pest since the early part of the eighteenth century. It attacks chiefly subterranean tubers such as potato, saffron, carrot and beet; in America it is also found on cotton. The researches of the past two years, carried out by Mr. Shaw and an account of which is now in the press, have shown that, in India, it is a parasite of wide range and, in some cases, extreme virulence. The species known as *Rhizoctonia Solani* Kühn, first described in 1858 on potato, appears to be most common. It occurs on potatoes at Bankipore, and on the Pusa Farm attacks jute, groundnut and cowpea. At Cawnpore it attacks seedling cotton and it has been reported on sesame from Surat. In some cases, *e.g.*, jute and cotton, the attack takes place in the seedling stage, when it is particularly virulent, in the case of jute the death rate in pot-culture being 70—80 per cent. The attack on cotton

was of interest as it proved to be identical with that known in Egypt as "sore shin" and in America as "damping off," both of which diseases were attributed by their investigators to an unnamed sterile fungus.

Special attention was paid to the possibility of the existence of biologic forms within the morphological species *R. Solani*. It was found that the race on jute was markedly different in its infective power from the fungus on cowpea, groundnut and cotton. The former would only infect its own host whereas the fungus upon either of the other three hosts could infect any one of the remainder.

A second species of *Rhizoctonia*, possessing much larger sclerotia, was found on groundnut and cowpea. It soon became clear that great confusion existed in the published literature between these two forms, which have been attributed to a single species under the name *Rhizoctonia violacea* Tul. The second form also occurs sometimes on potato, where it has been identified by American writers as *R. Solani* and stated to have a Basidiomycete, *Corticium vagum*, as its perfect stage. The investigations of the last year have confirmed the latter point but have shown that the fungus associated with *Corticium vagum* is a distinct and separate species. It is suggested that the name *R. violacea* may be retained for this form.

The fact that *Rhizoctonia* may live in the soil of an infected field for years renders the disease a peculiarly difficult one to combat. In Egypt a dressing of naphthalene has been found very beneficial in the case of cotton, while in England a weak solution of carbolic acid applied to the soil has given good results. The latter method is, however, too expensive for general use. It is fortunate that, so far, cereal crops appear to be immune to this disease and a careful rotation of crops is probably the best method of lessening its ravages.

(*c*) *Wheat rust.*—Last year was marked by a severe attack of wheat rust, the first for a number of years, in the Central Provinces. The disease was also prevalent in some

other wheat-growing areas, notably in Rajputana. Munshi Inayat Khan, senior Fieldman, was deputed to collect specimens and notes in the Central Provinces at the end of March. Examination at Pusa showed that, while all three varieties of rust were present, most of the damage was caused by "orange" rust (*Puccinia triticina*) and "black" rust (*Puccinia graminis*); "yellow" rust (*Puccinia glumarum*) was much less in evidence. Previous experience indicates that, in normal years, orange rust is absent or scarce in the Central Provinces, though common in Bengal and parts of the United Provinces. It appears, therefore, that in bad years this rust extends its area and much of the losses in 1912 must be attributed to it. In breeding rust-resistant wheats for the Central Provinces, yellow rust need not at present be taken into account. Black rust is always present and does much damage even in normal years; wheats resistant to this rust would be of undoubted value. As regards orange rust, the growth of wheats which withstand this variety would be a form of insurance against the occurrence of a rusty year. It is not, unfortunately, as yet definitely known whether wheats resistant to all three rusts can be produced. Meanwhile, as it is not possible in ordinary years to study the susceptibility of Central Provinces wheats in regard to orange rust, wheats which resist this rust in localities where it is prevalent might with advantage be introduced into the province.

(*d*) *Phytophthora investigations.*—Two species of this most destructive genus of fungus parasites have been under special study in the section. The first is *Phytophthora Colocasiæ* Rac., which attacks the common indigenous vegetable *kachu* (*Colocasia antiquorum*) throughout South-Eastern Asia. Its study was commenced by Mr. G. S. Kulkarni, Mycological Assistant of the Bombay Department, when a student at Pusa in 1909. It has since been continued by myself and its successful growth in artificial culture last year has allowed of the complete working out of its life history. It is hoped to publish the result of this work shortly. Mr. Dastur, First Assistant, has taken up the study

of a *Phytophthora* which attacks castor, as part of a larger investigation of the diseases of this crop. This species has also been got into artificial culture. The simultaneous production of the saprophytic habit by artificial culture in two species of this genus, until recently supposed to be exclusively parasitic, has permitted of important additions to our knowledge of the biology of the genus. *Phytophthora infestans*, the cause of the well-known potato blight, was found attacking potatoes and tomatoes at Jorhat in Assam; on a previous occasion, in 1902, it attacked potatoes in Burdwan and Hooghly Districts in Bengal. Ordinarily confined to temperate climates and always prevalent in the Hill Tracts of India, it is, perhaps, to be feared that a race is being developed which can withstand the heat of the plains.

(*e*) *Sugar-cane diseases.*—A memoir giving the results of the work of the past few years has been commenced. The difficulties encountered in carrying on field experiments, owing to inability to control external conditions which caused the partial loss of the crop on several occasions, have led to much loss of time. A good deal of information has, however, been obtained as regards methods of infection other than by planting diseased cuttings, both in red-rot and *Cephalosporium* disease, and it is considered advisable not to delay publication. This year's work includes these two diseases and also smut. Early in 1912 specimens of a cane disease which has appeared on the Jorhat Farm were received from Mr. Meggitt, Agricultural Chemist, Eastern Bengal and Assam, who laid stress on its resemblance to *sereh*, the disease which has caused more damage in Java than probably any other of the numerous diseases of this crop. The resemblance is indeed striking and a recent visit to Jorhat has not enabled me to identify the disease with any of those known in India. The symptoms of *sereh* are elusive, its cause is unknown, its treatment very troublesome; and the accurate identification of the Jorhat disease, so that measures for its suppression may be taken if necessary, is obviously a matter of the first importance.

(*f*) *Palm diseases.*—The " plague " of betelnut palms in Bengal and Assam has continued to spread to the north and east since first reported to Sir George Watt in 1896. Since 1905, when I visited Sylhet to attempt to discover its cause, it has extended to Cachar and Goalpara. Specimens from these districts, and from Khulna at the other extremity of the affected area, were examined during the year. The cause appears to be the fungus *Polyporus* (*Fomes*) *lucidus;* this species occurs commonly on dying palms and reasons were given in 1905 for supposing it to be parasitic. More recently it has been found on diseased areca and cocoanut palms in Mysore and Ceylon, and though its parasitism has not been conclusively proved, it is considered to cause disease in both localities. The losses in North-Eastern India have been enormous, but the area affected is so large as to render impracticable any attempt to check it on the lines of the successful work against bud-rot in Madras. The application of lime has been recommended and is reported to have had a beneficial effect.

(*g*) *Tea diseases.*—Mr. Shaw visited Cachar in December to investigate tea canker. The cause of this disease still, however, remains obscure. An *Exobasidium*, closely allied to that which causes " blister-blight " of tea, was discovered by Mr. I. H. Burkill in the Khasia Hills on *Camellia drupifera*, a wild relative of tea. I had some hope that this would serve to explain the spread of blister-blight from North-Eastern Assam to Darjeeling, but on submission to a specialist it was found to be a distinct species. Blister-blight was severe in parts of Assam this season and suggestions for further experiments to aid in its control were given to enquirers. The Scientific Department of the Indian Tea Association published an account of the suggested connection between the tea-seed bug (*Pœcilocoris latus*) and the fungus infection of tea seed, based on work carried out by me in the previous year. The section has been freely consulted by that Department during the year.

(*h*) *Indigo disease.*—A recrudescence occurred towards the end of last season of the so-called " wilt " of Java indigo

in Bihar, particularly where "moorhun" plant was kept for seed bearing. As there is much confusion between the condition due to the insect pest *Psylla* and that known as "wilt," a conjoined mycological and entomological investigation was undertaken. I visited the Research Station of the Bihar Planters' Association in November and examined the crop which had been kept for seed and which was at this date almost entirely destroyed. No sufficient explanation of the death of the plants could be found and it appears unlikely that it is due to a definite fungus parasite. As, on the other hand, it appears to be quite clear that Psylla does not kill the plant in this fashion, it is evident that further investigation is necessary. The preliminary stages of this were commenced last year.

(*i*) *Forest tree diseases.*—A large number of specimens of diseases of forest trees were received from the Forest Department. These included various pines, deodar, shisham, teak, "nahor," *Casuarina*, "sal," "mahua," *Cassia fistula*, mulberry, etc. In several cases the diseases were due to parasites already known and suggestions for treatment could be given. In others, notably the *nahor* disease in the Sibsagar and Teesta Divisions, the cause is a fungus which it has not yet been possible to identify and no recommendations can be made.

(*j*) *Other plant diseases.*—I visited Lyallpur in October to investigate the cause of the death of cotton plants in certain areas of the Government Farm. No parasite was found but evidence was obtained to show that the damage was due to root injury, resulting from the presence of an impermeable stratum some distance below the surface of the soil. A large number of specimens of cotton plants from fourteen villages in the wilt-infected area in Berar were sent for examination by Mr. Clouston. The percentage of wilt varied from over fifty to three. *Buri* cotton, so far, remains immune and Mr. Clouston is now working out how far this advantage compensates for its lower yield as compared with the varieties commonly grown. Mr. Shaw has investigated the disease of Sisal caused by *Colletotrichum*

Agaves and has prepared a note for publication. He also visited the Sisal plantation of Messrs. Allen Brothers near Cawnpore to report on its health. An outbreak of lucerne mildew was reported from the Remount Depôt, Sargodha, and of cauliflower mildew from Lahore. Experiments were continued with a view to finding some practical method of checking anthracnose of plantains. The stem rot of papaya was also under study, as its cause has not yet been determined. Mr. Shaw made a local investigation of the orange disease in the Khasia Hills, whence the " Sylhet " oranges of the Calcutta market are exported. The cause of this very obscure disease is still unknown. Oat smut was prevalent in Bihar and recommendations for its treatment have been made. A disease of coffee berries from Coorg was found to be caused by *Colletotrichum Coffeanum* Noack, a parasite which I had previously observed attacking the leaves of this plant, but which was not known to attack the berries. Mr. Shaw has commenced the study of *Striga*, a parasitic flowering plant which does much damage to sugar-cane, jowar and other Gramineæ in India. Amongst the diseases not previously known in India, cotton anthracnose, lucerne mildew and rust of velvet beans were the chief. Two diseases of wild vines were investigated, one of which is known to attack also the cultivated species. An account of them was published since neither occurs in Europe and, if introduced, they might prove serious pests in grape-growing countries. The usual routine work of dealing with enquiries and specimens sent in for report was continued. Altogether 98 parcels of specimens were examined.

5. *Systematic work.*—A considerable advance was made in this branch of the work of the section, the additions to the named herbarium collection numbering some hundreds. These were for the most part plant parasites, about 200 additions to the parasitic flora of India having been made. Two parts of the list of Indian fungi, which is being prepared in collaboration with Messrs. H. and P. Sydow of Berlin, were published. These contained the record, and in many cases also a detailed description, of over 300 species of

Indian fungi, of which more than a hundred were new to science. An account of an interesting aquatic fungus was also published. The total number of mounted sheets added to the herbarium was 779.

6. *Miscellaneous.*—I attended the meetings of a committee appointed to consider the question of preventing the importation of noxious insects and plant diseases into India, held at Pusa in November. It is greatly to be desired that action in this direction should be taken without delay. The measures recommended last year for checking the spread of lantana, a noxious weed in Mysore and Coorg, are under consideration and further information has been supplied to the authorities concerned. The section fitted up a stall at the Tirhut Agricultural and Industrial Exhibition held at Pusa in January, which was well attended. Assistance was given to the Government College, Lahore, in providing material and notes for teaching elementary mycology. An outbreak of dodder in clover was reported from Peshawar and recommendations for its suppression were made. I wrote the chapter on Mycology for the Annual Report of the Board of Scientific Advice for the year 1910-11.

7. Programme of work for 1912-13.

(1) *Research and experimental work.*—The investigation of the disease of paddy known as *ufra* in Bengal will be continued. Other diseases of paddy will be taken up as opportunity occurs.

Work on sugar-cane diseases will be continued. The disease which has appeared on the Jorhat Farm will be specially studied with a view to determining whether it is *sereh*.

It is proposed to examine the wilt diseases of cotton and sesame, in the Central Provinces, with a view to ascertaining their causes.

It is hoped to conclude the investigation of two species of *Phytophthora* and the diseases of castor and *Colocasia* caused by them.

The study of the so-called " wilt " of indigo will be continued.

The Supernumerary Mycologist is engaged in an investigation of some Phanerogamous plant parasites, especially *Striga*.

(*2*) *Training*.—This will be continued on the lines indicated in the Prospectus. Short courses will also be given if any students of the Institute wish to attend.

(*3*) Advice regarding the fungus diseases of plants will continue to be given to other departments, particularly the Provincial Departments of Agriculture and the Forest Department, and to the general public. The distribution of named specimens and other material to provincial colleges and other institutions will be continued.

(*4*) The collection and identification of Indian parasitic fungi will be continued.

8. Publications.

Fungi Indiæ Orientalis, Part III, H. & P. Sydow and E. J. Butler. Annales Mycologici, Vol. IX, No. 4, 1911; *ib.*, Part IV, Vol. X, No. 3, 1912.

On Allomyces, a new aquatic fungus, E. J. Butler. Annals of Botany, Vol. XXV, October 1911.

The rusts of wild vines in India, E. J. Butler. Annales Mycologici, Vol. X, No. 2, 1912.

A disease of Cotton, F. J. F. Shaw. Mufid-ul-Mazarain, September 1911 (*vernacular*).

Copper Blight of Tea, F. J. F. Shaw. Quarterly Journal of the Scientific Department, Indian Tea Association, Vol. I, Part 3, 1911 (reprint).

REPORT OF THE IMPERIAL ENTOMOLOGIST.

(A. J. Grove, M.Sc.)

1. *Charge and Establishment.*—The Imperial Entomologist, Mr. H. Maxwell-Lefroy, was away on long leave during the whole of the period under review. Mr. T. Bainbrigge Fletcher held charge of the section until April 19th, when he proceeded to Coimbatore to take up his new appointment as Entomologist to the Government of Madras. I joined my appointment as Supernumerary Entomologist on October 27th, 1911, and, since Mr. Fletcher's transfer, have carried on the work of the section. The First Assistant, Mr. C. S. Misra, has been in charge of all the field-work on the Pusa Farm and the botanical area, and of the arranging and carrying out of the lac work including the giving of two short courses in Lac cultivation. He has also assisted in the instruction of students in General Entomology and field-work. In addition to this heavy routine work, he has continued his investigations on the *Aleyrodidæ* and other Hemiptera. The Second Assistant, Mr. C. C. Ghosh, was on privilege leave from May 6th to June 30th, 1912. He has been in charge of the Insectary and has continued to carry out extremely useful work on many insect pests. Mr. G. R. Dutt, Third Assistant, has had the Economic Collections, records, correspondence and the distribution of coloured plates and lantern slides in his charge. In August 1911, he was sent to the Punjab and remained there for nearly three months organising and directing the campaign against the Cotton Bollworm. In this and his other work he has done admirably. Mr. Nowrojee, who was away on privilege leave from December 15th, 1911, to January 14th, 1912, has been in charge of the general collections and has done good work in arranging and keeping them in order. Mr. M. N. De had charge of the Silk House and has shown much interest in the work.

2. *Visitors.*—Mr. A. E. Andrews, Entomologist to the Indian Tea Association, worked in the Laboratory during the latter part of December and the beginning of January and again in February. Dr. A. D. Imms, Forest Zoologist, visited the section for a short time in January. Dr. H. Morstatt, Entomologist at Amani, German East Africa, worked for a time in the Laboratory. Mr. Johann Lang of the Basel Mission, Calicut, came to Pusa to acquaint himself with the details of Eri Silk culture and spent a short time working in the Silk House. Mr. Akhtar Mohammad Khan, Deputy Collector in the United Provinces, on special duty for silk work, visited Pusa during March to consult with the Officiating Imperial Entomologist.

3. *Training.*—The Assistant Professor of Entomology at the Lyallpur Agricultural College continued his course of training, but was recalled to his Province before this was completed. The Entomological Assistant in the North-West Frontier Province, after completing his course, remained working in the Laboratory until October 14th, 1911, and again from December 1st, 1911, till February 22nd, 1912, preparing show-cases of insect pests found in his Province. An Entomological and Mycological Collector to the Department of Agriculture, Bengal, was trained in Economic Entomology from August 10th, 1911, to February 22nd, 1912. A private student deputed by the Department of Agriculture, Travancore, for a course in General Entomology, was admitted on June 1st, 1912. Seventeen students attended the short courses in Sericulture; seven completed their course and five are still being trained. The two courses in Lac cultivation were attended by thirteen students.

4. *Provincial Work.*—The importance of work in the Provinces is now fully realised as indicated by the appointment of an Entomologist to the Government of Madras. There are, however, only eighteen assistants working in the Provinces and two are still under training. Under these conditions the progress of the work of demonstrating to the

agricultural classes the principles of Economic Entomology must necessarily be slow. Pusa has continued to assist the Provinces, whenever requested, by checking and advising upon the work of the assistants and in many cases the technical work has been referred to Pusa, leaving the assistants free to carry out practical work in the field.

In Madras a vigorous campaign was carried on against the Deccan Grasshopper, *Colemania sphenarioides*, Bol. Bagging and ploughing of infested lands were carried out and a leaflet detailing the methods to be adopted against the hopper was issued. Light-trap experiments for the moths of the Hairy Caterpillars were also continued. Eri Silk culture was started and its suitability as a cottage industry for Southern India tested.

In the Central Provinces, the experiments against white-ants were continued in collaboration with the Deputy Director of Agriculture, Northern Circle, Hoshangabad. From past experiments with the mound-building form of termites, oiling the nest with low grade kerosine oil (as ordinarily procurable in the bazaars) was found most effective. Tests were also made with the " Universal Ant Exterminator." Arrangements were also made with the Director of Agriculture, Central Provinces, for the despatch of parasites of the Cotton Bollworms to Lyallpur, and for some time the Entomological Assistant was engaged in collecting and sending out the parasitized bollworms to Pusa and Lyallpur. Early in August information was received from the Director of Agriculture, Punjab, of a possible outbreak of the bollworms. Arrangements were therefore made for sending out the parasites from Surat and Nagpur to an assistant from Pusa to organise the work at Lyallpur. An acre under cotton and two acres under *bhindi* were also sown at Pusa to establish the bollworm parasites. By the end of October the parasite (*Rhogas lefroyi*) was well established in the Punjab and a leaflet was issued in the vernacular of the Province, explaining how the bollworm should be dealt with.

In the United Provinces, active measures have been adopted against the Rice Grasshopper, *Hieroglyphus furcifer*, a serious pest to sugar-cane.

In Bengal successful demonstrations were made against the Potato Moth (*Phthorimæa operculella* Zel.) and the advantages of storing seed-potatoes under sand were demonstrated to the Kaoris as well as to others engaged in the potato trade. A leaflet, explaining the methods to be adopted against the moth, was distributed at Tirhut and Bankipore Exhibitions. The campaign against *Agrotis ypsilon* was continued. The picking off of the first brood of caterpillars and the setting up of Andres-Maire traps reduced the loss during the past year to a minimum, so much so that out of a total area of 20,000 bighas, only 2,000 were affected. Eri work was begun and the Department completed a Crop-pests Handbook.

In Eastern Bengal and Assam, the *Ufra* disease of paddy, probably caused by an eel-worm, was investigated.

In Baroda, the campaign against the *Katra* (Hairy Caterpillar) was continued. Practical demonstrations were made and rewards were offered to cultivators for keeping the field embankments clean as a preventive against the pest.

In the North-West Frontier Province, on the resumption of duties by the Entomological Assistant, a survey of the crop-pests of the Province was started and effective measures were taken against the Peach and Tobacco Aphides.

5. *Correspondence.*—The work of replying to the numerous requests for information and advice on the many branches of entomological work continues to demand much time and attention, but in view of the importance of this part of the work of the section, no efforts have been spared to give applicants as full information as possible. Seventy-eight parcels of insects were received for identification and suggestion of methods of treatment and this was done as far as we were able in each case.

6. *Research.*—The investigation of the habits and biology of insect-pests has been continued and among those studied may be mentioned the "Bherwa," the Fish Insect, White Weevil, Mango Leaf Hopper, Surface Grasshopper, Parasites of Cotton Bollworms, Cane Borer, Cane Fly, Wheat Stem Borer, Termites, Grain and Flour Beetles. The experiments on the preservation of wood and other materials from the attacks of Termites (white-ants) are still in progress and the efficacy of various preparations and the relative immunity of different kinds of woods are being tested. At the request of the Bihar Planters' Association, an investigation into the "Psylla" disease of indigo was commenced and is being continued.

7. *Insecticides.*—A number of preparations sent in for trial were tested and reported on. The first edition of Bulletin No. 23 on insecticides speedily ran out of print and a second edition revised and with some additions has been published. As many inquiries have been received as to where various insecticides and spraying machines were obtainable lists of the firms supplying these have been prepared and circulated.

8. *Sericulture.*—The experiments with crossing multi- and univoltine races of Mulberry Silkworms to procure a superior silk-producing multivoltine race have been continued but though many crosses were made, it has up to the present been impossible to produce a stable multivoltine race, although as mentioned last year some improvement has been obtained in the quality of the silk.

Univoltine European races were successfully reared on pruned tree mulberry, wild mulberry and bush mulberry and arrangements have been made to distribute eggs of these univoltine races for rearing in October. The difficulty with these eggs is that the temperature of the plains is too high to preserve them successfully during the dormant period and arrangements have been made to send the eggs to places in the hills where the temperature is not so extreme.

The Eri Silkworms were reared successfully throughout the year except in May and June, when, owing to the

extreme heat and dry conditions, the worms did not thrive and disease broke out in the cocoon stage, necessitating the rejection of the majority of the eggs obtained.

Numerous requests have been received for disease-free Eri and Mulberry Silkworm eggs, samples of cocoons, thread and cloth, pamphlets, castor seed and mulberry cuttings and seeds, and these have been complied with whenever possible.

Exhibits were sent to the Bankipore Exhibition and to the Exposition held in connection with the Anniversary of the Calcutta Scientific and Industrial Association. A demonstration of Eri and Mulberry Silk rearing, reeling, spinning, weaving, etc., was given at the Tirhut Agricultural Exhibition held this year at Pusa.

One drawback to the progress of the Eri Silk industry is still the difficulty which small rearers have of getting rid of the cocoons when they have obtained them, as the mills will only take large quantities for spinning.

9. *Lac-culture.*—The work of collecting and sorting the specimens of lac insects, received from the various Forest Range Officers, was continued. Experiments in lac culture were again carried out and two short courses on Lac cultivation were given, thirteen students receiving instruction. Numerous enquiries were received and answered regarding the cultivation, and brood-lac was supplied to a number of applicants. Inoculated *Ber* and *Kusumb* plants were also sent to Japan. An exhibit, showing the details of lac-culture, was sent to the Tirhut Exhibition held at Pusa and copies of a leaflet on the subject written in the vernacular were distributed.

10. *Apiculture.*—Two more colonies of American Italian bees were obtained from England in November 1911 and have proved very successful from the honey-gathering point of view, but so far, all attempts to obtain fertilized queens for multiplying the colonies have failed, apparently largely owing to the activities of certain bee-eating birds. The experiments will be continued, as it is important to determine whether it is possible to multiply the colonies in this country. Experiments have also been made with the

common Indian bee, *Apis indica*, and attempts have been made to accustom it to the modern bar-frame hive. These in a measure have proved successful, but progress is slow largely owing to suitable appliances not being available and more experiments are necessary before a definite opinion can be expressed. Several enquiries have been received with regard to apiculture and these have been answered as far as possible.

11. *Demonstration.*—The work of adding to the number of coloured plates of insect pests was continued and the new ones issued to the Provinces. A number of complete sets of coloured lantern slides were also issued. As mentioned previously, exhibits were sent to several Exhibitions.

12. *Insect Survey.*—Additions have been made to the general collections. Unnamed specimens of *Tettigidæ*, *Passalidæ*, *Cantharidæ*, *Rutelinæ* and *Psyllidæ* have been sent to specialists for identification and many of the collections sent out last year have been received back with the required information. Specimens have been identified for Provincial Assistants, the Indian Museum and many private collectors.

13. Programme of work for 1912-13.

As in previous years the work of investigating and advising upon insect pests will be continued. Assistance will be given, when desired, in co-ordinating the work of the Provincial Assistants and special help will be given in case of any serious outbreak. The preparation and issue of coloured plates and lantern slides will be proceeded with as before. The short courses in Lac cultivation and Eri and Mulberry silk-culture will be continued. Further experiments will be made with European and Indian bees. It is hoped that the collections of lac insects will be completed during the period. Eri silkworms will be reared and requests for help and advice will be complied with as far as practicable. The experimental work with Mulberry silkworms will be continued. New insecticides and apparatus sent in for trial will be tested and reported

upon. The field experiments with wheat and sugar-cane will be continued and further experiments have been commenced and will be carried on with a view to test the relative immunity of different varieties of cotton to the bollworm and also to extend the observations on the bollworm parasite.

14. Publicatons.

The following is a list of publications which have appeared during the period under review. As material accumulates, other Memoirs on the life-histories of insects will be prepared. Several Memoirs are now in preparation and include life-histories of *Orthoptera*, *Hemiptera*, *Lepidoptera* and *Coleoptera*. The revision of *Insects injurious to Indian Agriculture* is being proceeded with.

LIST OF PUBLICATIONS.

The Food of Birds in India. C. W. Mason, edited by H. Maxwell-Lefroy. January, 1912.

Eri Silk. H. Maxwell-Lefroy and C. C. Ghosh. May, 1912.

Life-histories of Indian Insects II. Some Aquatic Rhynchota and Coleoptera. D. Nowrojee. April, 1912.

Life-histories of Indian Insects III. The Rhinoceros Beetle (*Oryctes rhinoceros*) and the Red or Palm Weevil (*Rhynchophorus ferrugineus*). C. C. Ghosh. December, 1911.

Second Edition of Bulletin No. 23 on Insecticides, by H. Maxwell-Lefroy, revised with many additions, by T. Bainbrigge Fletcher. May, 1912.

Grasserie in Silk-worms. M. N. De. Agri. Journal, July, 1911.

Weevil and Dry Wheat. T. Bainbrigge Fletcher. (Agri. Journal, October, 1911.)

A Simple Honey-extractor. T. Bainbrigge Fletcher. (Agri. Journal, October, 1911.)

The Wax Moth. T. Bainbrigge Fletcher. (Agri. Journal, October, 1911.)

The Cabbage White Butterfly. T. Bainbrigge Fletcher. (Agri. Journal, January, 1912.)

Article on Litchi Mite. C. S. Misra. (Agri. Journal, July, 1912.)

Leaflet on the Bollworm in Cotton (*Gurumukhi*). October, 1911.

Cotton Bollworms in the United Provinces (Vernacular). C. S. Misra. January, 1912.

The following are in the Press:—

Memoir on Tetriginæ. Dr. J. L. Hancock.

Memoir on Life-histories of Hymenoptera. G. R. Dutt.

Memoir on the Big Brown Cricket. C. C. Ghosh.

Bulletin No. 28 on the Cultivation of Lac in the Plains of India. C. S. Misra.

Bulletin No. 29 on Eri Silk.

REPORT OF THE IMPERIAL PATHOLOGICAL ENTOMOLOGIST.

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

The programme for the past year has been considerably modified in consequence of the much closer relation with medical work which now exists. I am indebted to the Administrators of the Medical Research Fund for the addition of three posts to my staff, of which two have already been filled. These extra men will be engaged exclusively with "medical" entomology, and there will thus be at least two men available for Veterinary, Agricultural, and general work. The provision of these posts has rendered the question of accommodation more acute than ever, and a portion of the extra space required has been provided by the erection of a small supplementary laboratory now completed.

I have already put forward certain suggestions for the establishment of a medico-entomological laboratory for Northern India where entomologists and medical officers could work at any group of blood-sucking insects under the best conditions for obtaining material and observing the living insects in their natural habitat without undue risk to health. Such a laboratory should be in a district where blood-sucking insects attain their maximum abundance and variety: examples of such tracts are the lower slopes of the Himalayas and the Western Ghats and certain parts of Assam. It should be in some place having a climate sufficiently cool to allow of operations such as section-cutting to be carried on without inconvenience at any season, but should be on a railway or good road affording easy access to tracts where insects abound. The establishment of such a laboratory at some place fulfilling these conditions (*e.g.*, Shillong, the Kurseong neighbourhood, the Naini Tal road from Kathgodam, Igatpuri) would not necessarily entail any large expenditure if a site were available, and would

enable observations to be carried on with a facility unobtainable at any existing laboratory known to me, with the possible exception of Coonoor and Madras.

The work of the section has been largely concerned with mosquitos, and the life-histories of eighteen species of Pusa mosquitos have now been worked out. Special attention has been paid to the genus *Stegomyia* and allied forms, and a five weeks' course of instruction has been given to medical officers deputed to the "Stegomyia-survey" in connexion with the possible future importation of yellow fever. Seven officers attended the course. The most interesting point discovered regarding *Stegomyia* life-histories is that during cold and dry weather the two commoner species at Pusa (*S. scutellaris* and *S. thomsoni*) survive normally as dry eggs and not as active, hibernating, or æstivating adults. This has an important bearing on the practical question of checking the increase of *Stegomyia*.

Investigations have been begun on general mosquito bionomics, the main heads being the influence of temperature on mosquitos; methods of colouring or otherwise marking mosquitos in order to study their movements, and the range and rate of flight under natural conditions; sexual reactions of mosquitos; new larvicides; the food, feeding, and digestion of mosquito-larvæ; fish and other enemies of mosquito-larvæ. The difficult question of the breeding-places and habits of *Phlebotomus* has been taken up. A possible association with Termites may prove of importance.

Simulium-infested streams at Simla were examined with a view to finding methods of decreasing the numbers of the fly, but local conditions are such that no cheap method seems applicable. The life-history of the Crab-louse (*P. inguinalis*) was worked out (apparently for the first time), and its curious habits studied.

Other subjects which received attention are the parasites of *Tabanus albimedius* and of *Monophlebus stebbingi* var. *octocaudata*, the nature of the attraction of citronella oil for fruit flies of the genus *Dasyneura*, the life-history of *Celyphidæ* and improvements in mosquito-traps. The

East Indian Railway school at Jharipani was subjected to hydrocyanic acid fumigation on account of a plague of bugs, and the result appears to have been satisfactory.

As Secretary of the Entomological Sub-Committee appointed by the Malaria Conference in Bombay, I assisted in drawing up a scheme for organising work in pathological entomology.

A hand-book dealing with methods of drawing and reproducing illustrations for scientific papers has been passed for publication.

Programme of work for 1912-13.

The programme for the ensuing year will be subject to modification in accordance with any special requirements on the medical and veterinary side: Directors of Agriculture are being circularized in order that we may ascertain whether with respect to the latter there are any particular directions in which investigation is required. The special lines of work suggested by the Medical Department are mosquito bionomics and the breeding-habits of sandflies: both of these will be continued, and will in all probability form the major part of "medical" investigations; the former subject alone is one to which several years of work might be devoted. It is suggested that an appeal should be circulated throughout the country to enlist helpers and stimulate interest in medical entomology, and that specimens and information received should be dealt with either at Pusa or Kasauli; details of the arrangements are still under consideration, but at least some part of the work in this connexion would be done at Pusa.

Identification of specimens and any other work that may be required in connexion with the "Stegomyia-survey" will be undertaken, and more detailed observations of these mosquitos will be carried on. Experiments on methods of checking their increase have been begun at Pusa, and will continue until the onset of the cold weather.

An attempt will be made to elucidate the nature of the influence of citronella oil on fruit-flies: some unexpected

results were obtained in the course of the past summer, and a clearer understanding of the matter is desirable in view of the wide distribution of these flies and the serious damage they inflict in various countries.

REPORT OF THE IMPERIAL AGRICULTURAL BACTERIOLOGIST.

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

I held charge of the section throughout the year.

1. *Charge and Establishment.*—The First Assistant Mr. N. V. Joshi was on privilege leave from October 9th to 23rd December 1911 and the Second Assistant Mr. K. S. Viswanatham was on privilege leave from April 9th to 29th June 1912.

All the Assistants in the section showed great interest in the work, and not only worked daily several hours overtime but made themselves sufficiently familiar with French and German to be able to read and make translations into English from papers published in these languages.

2. *Tours.—To Rangpur* to observe the conditions of incidence of bacterial disease of tobacco.

To Jorhat to see the manurial experiments carried out by Mr. Meggitt and the new Experiment Station of the Indian Tea Association.

To Dacca to consult Mr. Finlow on the subject of bacterial action in jute retting and "heart damage."

To Lyallpur to consult Mr. Barnes on the subject of "Reh" soils and to deliver a course of lectures on soil bacteriology.

3. *Soil Bacteriology.*—The work of the Bacteriological Section at Pusa during the year has been mainly directed towards ascertaining what factors determine biologic activity in Indian soils, and to the measurement of the changes resulting therefrom under various conditions. The main problem so far dealt with has been the supply of available nitrogen as provided by the biolysis of such substances as green manures, root residues, and organic manures. No work has been done upon nitrogen assimilation by Legume bacteria or such organisms as Azotobacter, Clostridium, or Rhizobium.

The method of determining the biologic activity of a soil by plate counts has been abandoned in favour of methods depending upon measurement of the physiological activity of the soil organisms. By the use of such methods biological analyses of soils may be carried out which will provide indications as to their relative capabilities for dealing successfully with organic manures. Far more valuable information, however, is also obtained by such analyses. By the use of fairly large portions of soil it is perfectly feasible to set up and maintain conditions of moisture and aëration comparable with those in the field, and to determine in the laboratory for any particular soil under what conditions of water supply, tillage, and addition of lime or manures, either natural or artificial, the greatest amount of ammonification and nitrification will result.

It has been ascertained by numerous experiments that the rate of formation of carbon dioxide in a soil is directly proportional to the biologic activity of that soil, and that conditions unfavourable to the latter will also adversely influence the former. A simple method of measuring the rate of formation of carbon dioxide in soils under various conditions has been devised and by this means it is possible to determine what moisture content of any particular soil is the optimum for bacterial activity; this has been found to vary from as high as 37 per cent. in one case to as low as 16 per cent. in another. By the same method the effect of the addition of various manures, organic or mineral, may be observed, and it has been found possible in this way to prescribe the addition of certain substances, such as lime or superphosphate, to a soil in order to promote the decomposition of green manures, oil-cake, or cattle manure buried in it. Similarly by determining the optimum moisture content, recommendations can be made as to variations in field practice which would tend to dry out the soil in one case or to conserve moisture in another; a very large number of observations have been made as to the conditions under which ammonification and nitrification take place in

Indian soils. It has been found that important differences exist between the biological changes taking place in the latter and those which have been observed in the soils of Europe; these differences appear to be due to the high average temperatures of Indian soils and their consequently high relative rate of bacterial action. In soil at temperatures between 15° C. and 18° C. the process of ammonification, which is the natural and necessary predecessor of nitrification, takes place at such a rate as to allow the latter to proceed *pari passu;* in many Indian soils, however, it has been found that at the higher temperatures 25° C. to 30° C. which obtain in them for many months in the year, ammonification may proceed with such rapidity as to produce a concentration of ammonia in the soil water sufficiently high to interfere with nitrification or even to inhibit it altogether. Where large quantities of nitrogenous organic matter are turned into the soil and put under intensive cultivation much nitrogen may be lost in the form of ammonia, and experiments have shown that the biolysis of organic nitrogenous material requires very careful investigation from this point of view.

It is evident that these facts must be taken into account in selecting the time of year for applying organic manures, along with other considerations depending on local meteorological conditions and the optimum moisture content of the soil.

Further experiments have demonstrated another source of loss of nitrate nitrogen. It has been shewn that where intense bacterial action is taking place in soil any nitrates present will be reduced without the occurrence of anærobic conditions; it appears probable that the nitrate is utilized as a source of nitrogen by the bacteria. It was found, for instance, that in Pusa soil the optimum moisture content for nitrification is 16 per cent. whereas general bacterial action is intense up to 25 per cent. and at the latter figure rapid reversion of nitrate to the protein form takes place. This would help to explain observations made in field practice both at Pusa and in the Punjab, that excess of soil

moisture produces nitrogen starvation of the wheat crop; the importance of biological analysis of irrigated soils by such methods will readily be realized.

A special enquiry has been carried on and is still proceeding, to determine the conditions under which bacteriotoxins are formed in soils and their effect in inhibiting bacterial action. The work of Greig Smith of N. S. Wales on this subject has demonstrated its importance, and experiments at Pusa have fully confirmed his views. Mr. Meggitt, Agricultural Chemist, Eastern Bengal and Assam, with whom I hope to collaborate on this subject, has carried out a series of investigations on similar lines, but the enquiry is not sufficiently complete for detailed report.

A complete series of experiments on green manuring was designed and commenced, in collaboration with the Imperial Agriculturist. This included observations in the field and in the laboratory as to the effect of varying treatment of the green crop (*Crotalaria juncea*) upon the condition of the soil and upon the succeeding crop. Field variations included burying after varying periods of growth, at different depths, and in conjunction with various artificial manures. Laboratory experiments were carried out to determine the rate and kind of change of the buried organic material under various conditions, with special reference to the formation of nitrate, and in order to obtain data which might help to elucidate the problems connected with the occasional failure of green manuring to improve soil conditions.

This enquiry will continue over two more seasons.

4. *Plant Pathology.*—A bacterial disease of tobacco at Rangpur was investigated and found to be due to an infection of *B. Solanacearum.* The strain isolated was found to be also pathogenic to *Solanum Melongena*, Tomato, Datura and Potato. The incidence of the disease at Rangpur and Burirhat was not apparently associated with any insect attack or specially unfavourable soil conditions, and was not heavy enough to cause apprehension as to future spread. The parasitism of the causative organism as

isolated from diseased plants in the field was found to be insufficiently strong to attack healthy plants, although by passage through several individuals or by artificial culture on Potato it could be raised to a high degree of virulence. For this reason the practice of leaving the plants in the ground for a second cutting should be avoided in infected areas.

A bacterial disease of wheat in the Punjab, locally known as "Tannan" or "Tandu," was investigated; this was found to be due to the attack of a bacillus closely resembling *Ps. Hyacinthi* which invests the opening ear with a sticky growth causing deformation and stunting and preventing ripening of the grain. The attack is confined to small badly drained areas and can probably be avoided by proper cultivation; its distribution is limited and it is probably of no economic importance.

5. Programme of work for 1912-13.

Work on influence of soil conditions upon nitrification will be continued.

A new line of enquiry will be commenced this year with the object of determining the conditions under which nitrogen fixation by so-called non-symbiotic organisms may balance losses of nitrogen due to various causes under agricultural conditions.

The green manuring experiments will be continued in collaboration with the Imperial Agriculturist.

Should time permit an attempt will be made to obtain more precise data as to the effect of variations in temperature, moisture, and aëration upon nitrification in soils with special reference to field conditions and agricultural practice. The apparent inhibitory action of various crops will be taken into account, and the effect of different systems of cultivation upon aëration and moisture content of soil.

Work on formation of soil toxins and their influence upon bacterial action will be continued. It is hoped that this may be done in collaboration with Mr. Meggitt.

Experimental work on the "Ufra" disease of Paddy with reference to soil conditions will be continued.

Indigo wilt.—This will be investigated with a view to the possibility of its bacterial origin.

Training of students will be continued.

6. List of Publications.

Hutchinson, C. M.—Studies in Bacteriological Analysis of Indian Soils—No. 1, 1910-11 (Mem. Dept. of Agriculture in India, Bacteriological Series, Vol. I, No. 1).

ANNUAL REPORT OF THE IMPERIAL COTTON SPECIALIST.

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

I held charge of the appointment throughout the year. The first two months were devoted to the establishment of the series of experiments on which I had decided to work out the manurial requirements of the cotton plant in India and the differences which may perhaps accrue from the presence of various manurial ingredients in the soil. This enquiry will only give data for estimating results in the course of a few years.

In September and the early part of October I visited the Mysore State to suggest some preliminary lines of experiments. The greater part of October was devoted to a tour in the Punjab and the United Provinces.

In November I visited Berar and then attended the Conference of the Agricultural Board at Pusa where I had opportunities of discussing cotton work with members of all the Agricultural Departments in India.

In January I visited Assam to advise a planting firm regarding the cultivation of cotton in that Province.

During the intervals throughout the year I was engaged in supervising my own experiments and in advising, with some degree of detail, more than twelve correspondents in India and other parts of the East, on special points connected with the cultivation of cotton.

To further my botanical researches I obtained seeds of the indigenous cottons in the Kashmir State and the varieties of wild cottons existing in Sind.

A number of cotton samples were exhibited and explained at the Mysore Industrial Exhibition. For these the committee awarded a diploma and the notes accompanying the exhibits were considered sufficiently useful to be quoted in full in the Exhibition catalogue. A set of cottons were sent for exhibition in the North-West Frontier

Province, by Mr. Robertson Brown, who considered that the quality of the samples would help the cultivators to realise how cotton should be turned out for the market.

To simplify this Report for purposes of reference I give the information I have gathered from each Province separately.

The Central Provinces and Berar.—Mr. Low, the Director of Agriculture, at the general meeting of Agricultural Associations at Akola, in November, ably summarised the present condition of cotton cultivation in his Province and, as this paper was presumably only for the information of members and visitors and will probably never attain general circulation, I take the liberty of transcribing such portions as pertain to my subject. Having been honoured by being allowed to follow closely the work done in the Province, since its initiation, I can vouch for the accuracy of the details, and the importance of the subject requires no apology for its introduction.

The centre of cotton work is at the Akola Experimental Station, which was opened six years ago. Great care was taken to select uniform areas for the different series of experiments. This was done by growing *juar* over the whole area to start with and by selecting areas of uniform fertility as ascertained by experimental weighings. Where the land was found to be uneven in fertility, as proved by variations in the outturns, it was discarded as being unsuited for experimental purposes.

From the experiments, which have now been going on for five years, several very practical lessons have already been learnt. These are being carried into practice in the non-experimental areas and are also being recommended for adoption by other cotton growers. It has been proved that the turn wrest plough is an excellent implement for eradicating weeds and for deep and thorough cultivation generally; that the Hoshangabad iron tined *bakhar* is a very useful implement for uprooting cotton stalks in the field before preparing the land for the next year's crop; that the Akola hoe is a better implement than the Berar *doura* for

interculture as it produces a deeper tilth in the black cotton soil. Turn wrest ploughs will, in future, be made in India by Messrs. Burn & Co., Calcutta, and agents have arranged to stock them at the various cotton centres.

Much attention is being paid to experiments with the different manures on this farm and the excellent crops that clothe the fields are largely the result of high manuring.

Most cultivators in this Division grudge to pay even 12 annas for a cart-load of cattle dung; its manurial value for cotton is at least twice that. The cultivator who neglects to manure his land is a loser because by withholding one small item of expenditure, namely, manure, he lessens very considerably the effectiveness of the other items, *viz.*, cost of cultivation, seed and supervision. Increased outturns have been obtained on the farm from the use of cattle dung, poudrette and saltpetre as manures for cotton and *juar*. The most economical of these is poudrette which is obtainable in fairly large quantities from all the large towns in Berar. A source of manure which is neglected all over India at present is cattle urine when conserved by the dry earth system. It has been proved at Akola that, for cotton and *juar*, the manurial value of a farm animal's urine is equal to that of its dung and by conserving the liquid manure, the value of the manure available on a farm can be doubled.

Nitrogenous fertilizers, such as nitrate of soda and saltpetre, when used as a top-dressing after the application of cattle dung, have also given very good results. It will pay to use them as a manure for cotton to supplement the inadequate supply of cattle dung so long as the price of that staple remains high.

The quantity of lint yielded by each variety varies from $36\frac{3}{4}$ seers per acre for *bani* to $80\frac{1}{2}$ seers for *rosea*. As the value of a cotton depends very largely on the quantity of lint which it gives, *rosea* stands easily first and *bani* is distinctly the poorest yielder. The advantage to be gained by growing *rosea* in preference to Berar *jari* is that it gives

more *kapas* and a higher percentage of lint. A profit of about Rs. $11\frac{1}{2}$ per acre is made on this farm by growing *rosea* instead of Berar *jari*. *Malvensis* also does well in certain localities and the lint is much superior to that of *rosea*, but it is a less profitable variety to grow owing to the lower percentage of lint which it yields.

Vera closely resembles *malvensis* and *cutchica* somewhat resembles *rosea*.

Bani or *Hinganghat kapas* is, from the point of view of quality, one of the best cottons grown in India, but it gives less than half as much lint as *rosea* and buyers are not willing to pay more than from 20 to 30 per cent. more for its lint than for that of *rosea*. Consequently it is hopeless to expect that it can be grown as profitably as *rosea*. The only chance of improving it with effect seems to be to raise the ginning percentage. The strain, evolved by selection on the farm gives 3 per cent. more lint than ordinary *bani*.

Bhuri is the best exotic cotton yet tried in the Province. It is entirely resistant to wilt which is now doing considerable damage to Berar *jari* in certain parts of the Division. *Bhuri* is recommended for such areas and for the rich *khari* lands of the villages. It suffers more from drought than Berar *jari* but less from excessive rain. Before this farm was opened the terms *rosea*, *malvensis*, *cutchica*, etc., were quite unknown, but now these are household words in Berar and many cultivators are growing these varieties pure for seed distribution.

Rosea is being grown on 31 seed farms in this Division; *malvensis* and *cutchica* on 4, *bhuri* on 33, and it is reckoned that there are 5,000 acres under this new variety in Berar alone this season. It is gratifying to note that all this has been accomplished by the Department of Agriculture, mainly through the agency of the Akola Farm, within the short space of five years, and that these different varieties had never been grown pure previous to that time. Several cultural points have also been decided, such as that topping

cotton reduces the yield, that the best spacing distance for Berar *jari* is 15 inches apart for the rows and 7 inches apart for the plants in the rows, that cotton sown before the monsoon breaks gets a good start and gives a larger yield than that sown after the rains have set in, if the blanks are dibbled in.

Mr. Clouston adds that cotton grown continuously in the same field for a period of years has become a fairly common practice in Berar. This disregard of the principle of rotation in cropping is decried by scientists, who attribute to it the spread of insect pests and fungoid diseases. The results, up to date, however, have not justified that assumption. The experiment has now gone on for four years; no trace of disease and no serious damage by insects have yet been noticed. Economically the practice has proved a sound one owing to the high price of cotton and it is, therefore, being followed in the non-experimental area of the farm.

Finally, the increasing demand for pure *rosea* seed has been very marked. The Department admit that, in this part of India, *bhuri* cannot be grown at as large a profit as *rosea*, except in wilt-infested, wet or *khari* areas. Cambodia cotton gives a poor return. It is more than a month later than the indigenous varieties and suffers from the early cessation of the rains in Berar.

In my last year's report I explained the good work that is being done at the Khandwa Agricultural Station by Mr. G. Evans, the Deputy Director of Agriculture, Northern Division, Central Provinces. This year he has furnished samples of five sorts of cottons grown at the same station and of two samples which he has picked out during his researches throughout his District. One is from Chhapara, a high plateau in the Seoni District of the Satpura, and the other from Patan in a part of the Jubbulpore District which is liable to early frost. He considers from the geographical situation of both tracts that an early ripening variety is absolutely essential. From the valuations it

is evident that these tracts already possess a fairly valuable cotton.

Messrs. Tata, Sons & Co. have kindly furnished me with the following valuations and remarks on all the above-mentioned seven samples :—

Valuation furnished by Messrs. Tata, Sons & Co., Bombay, on the seven samples of cotton from Khandwa, on 20th February 1912.

Serial No.	Name of sample.	Remarks.
1	*Bhuri*	Compared with local cotton of Khandwa this cotton is far and away superior. It is soft and silky in feel and has a fine long fibre. It is more like the Bassim cotton of the tableland. Taking Akola as our basis for valuation at Rs. 275 we value this cotton 15 rupees higher, say Rs. 290.
2	*Malvensis*	Same style of cotton as No. 1, but the length of the fibre is slightly shorter though the staple shows more strength. Same value as above, *viz.*, Rs. 290 per candy.
3	*Cotton from Chhapara* .	Bengal style of cotton, but of superior quality for which we value it 10 rupees higher than Fine Bengal, *viz.*, Rs. 280 per candy (Bengal Fine Rs. 270).
4	*Saugor jari*	Same style as No. 6, but a shade better and more even in staple. Value Rs. 275.
5	*Local*	Same as No. 4. Value Rs. 275.
6	*Roseum*	This cotton is equal to local Khandwa cotton and shows no improvement. Value same as for local Khandwa cotton, *i.e.*, Rs. 270 per candy.
7	*Patan*	Punjab style of cotton. Compared with No. 3 it is inferior in colour but a shade better in staple. It is more like fine Mooltan cotton. Value Rs. 265.

Punjab.—I visited the Punjab in October and completed a joint inspection of the cottons of that Province, with Mr. Milne, the Economic Botanist.

There are two varieties of the dark flowered and broad lobed *G. sanguineum*, one with dark, the other with green

stems. Great variations in staple are found in these plants. Selection experiments have proceeded probably as far as they can be taken and the staple obtained attains the length of ·8 inch. It has been proved that the shortest staple is associated with the hardiest and darkest coloured plants. Excepting the characteristic of coloration which is a negligible factor in other parts of India, the above fact is a further confirmation of our experience that hardiness and poor staple are companion characters.

The variety which I have already published under the name of *G. obtusifolium* var. *hirsutior* seemed to be unsuited for cultivation owing to its prolonged season of growth, but it may yet prove useful in cross-breeding.

The remaining indigenous forms of Punjab cottons are yellow and white flowered forms of *neglectum* and *indicum*, all, however, with a strong tendency to show true *neglectum* characters.

Khaki hirsutum is unsatisfactory from its producing cotton of varying tints and many bolls bear quite white cotton. A good, even, white colour is a desideratum in a cotton produced for sale in the Indian market and buyers are prejudiced against coloured cottons.

Of the indigenous types the broad lobed *sanguineums* are by far the most promising and it would be well to draw the attention of the cultivators to these as they are of a particularly desirable type. The outturns of all the plots appear to be excellent.

The Upland cottons were described to me by an American expert as being the best he had seen outside the United States.

Two varieties come into bearing as early as the indigenous cottons, but it is still to be seen whether they are quite early enough to save one watering or not and this is a matter of important consideration to the zemindar. The successful introduction of these cottons into more general

cultivation will, of course, depend on the willingness of the selected zemindars to devote more careful attention to cultural methods than they at present exercise in the case of their *deshi* cottons. The valuations received on these cottons show, by a comparison of outturns, that the most highly priced varieties are by no means the most profitable to grow.

Mr. Conville, a local cotton merchant, mentioned that during this year he had observed a great improvement in the cultivation of cotton in the Colony and he attributed this advance to the good example held out by the Lyallpur Farm. He considers that the bad practices of cotton sellers and buyers, ginneries, etc., have helped to lower the prestige of Indian cottons.

Mr. Miliades says that in his long experience of Lyallpur, the yield of cotton has fallen from 10 to 12 maunds to 4 or 5 maunds per acre. He thinks that this decrease is wholly caused by the diminishing fertility of the soil which was practically virgin land only a few years ago. Mr. Milne explained to me that the natural indigenous vegetation of the tract before the days of irrigation consisted mainly of leguminous plants and that the cotton yielded its maximum while the plants could draw on the nitrogen stored in the soil. His idea of introducing Berseem or Egyptian clover as a fodder and a renovator of the soil is a sound one and I shall follow with interest the results of his experiments. The deterioration of some well-known staples in the Punjab is said to be due to careless cultivation and treatment. Multan cotton (a pure *sanguineum*) is a hardy cotton capable of producing full crops on the western side of the Province. Mr. Miliades considers that even now, in many respects, he prefers this cotton to the *Narma* or acclimatized Upland cotton.

Mr. Roberts is growing on a field scale what has been handed over to him by the Economic Botanist and he already has urgent demands for select seed from the cultivators. This is, in itself, sound proof that the cultivators realize the value of what is being done for them. The

maintenance of pure types in their hands, however, is the most difficult problem confronting the Department and it is impossible to foresee at present how it can be solved. A due appreciation of the difficulties of this task leads us to the conclusion that, although a number of varieties can be safely tried on a small scale, for distribution purposes it would repay the Department to work with one *deshi* and one American only. Afterwards when it is known that special tracts require their own special varieties, then the safest course to pursue would be to establish seed farms on these areas. This has been already successfully accomplished in the Central Provinces.

Messrs. Tata & Sons of Bombay have courteously given me a report on Punjab cottons drawn up by one of their agents who was buying Upland cottons. The following is the gist of it : " The *deshi* and American cotton grown in the Lyallpur District have been deteriorated by boll weevil and frost and in some parts large tracts of cotton fields have been totally destroyed. The total crop in this district would be about 10,000 to 11,000 bales, whereas last year it was about 35,000 bales. The general complaints about the *kapas* this year are large percentage of unripe *kapas*, yellow stains from boll weevil and short staple. These tend to give decreased outturn and dull colour. The cultivation of American cotton is not yet universally taken up in the whole district. It is chiefly grown on the horse-breeding farms, called Risala, the Agricultural Farm and by a few private farmers. The crop of Risala No. 15 is the best in the district this season. The seed was obtained from the Agricultural Farm, which obtained it from Dharwar some years ago. On the whole the quality of this cotton is good except that no care seems to have been taken in picking. The fibres are strong and pliable and the regularity in their length would enable good yarn up to 24^s to 40^s to be made in warp and weft. I am sorry I am not able to make the same remarks on other American cottons grown in the district.

"I have seen several samples of American cotton grown by farmers and have not seen any equal to that of No. 15 Risala. Generally there is an apathy to cultivate American cotton as it gives less percentage of lint and requires more care than *deshi kapas*. The Agricultural Farm is striving hard to select such American seed as would suit the climate and give a large percentage of lint and long stapled cotton. During the short time of its existence it has distributed various sorts of American seeds among the farmers and hence the trouble, as many of the American varieties are not suitable to the climate. The farmer also gives the American the same treatment as his *deshi* sorts. As the fibre of the American cotton is very thin and fine, special care is essential in picking and handling. The method of storing the *kapas* is also very defective, and this defect is not only found among the uneducated farmers as I was surprised to see the *kapas* of the Agricultural Farm stored in large, iron cisterns about 15 to 20 feet high. The stuff was not loosely packed but it was pressed hard, a procedure which is sure to spoil the staple and colour and increase the waste in the blow-room. If a proper method is pursued throughout there is a splendid future for American cotton in this district. The soil is rich and, from the farmer's point of view, the soil that gives good wheat can also yield a good cotton crop. It may be that the improvement cannot be achieved in a few years, but the picking can be improved now, if more care be taken. To make the American cotton grown in India commercially successful it is very essential indeed that particular care should be taken in picking. I send you two samples of cotton, both from the same farm (No. 15 Risala) and from the same seed. The only difference between them is that the former was carefully picked and such a sample can be commercially classed as F. G. M.; the latter, though equal in staple and regularity, can be classed between L. M. and Med."

In a further communication Messrs. Tata, Sons & Co. have given me the results of the working of Lyallpur cotton, compared with American, *bani* and *bhuri* types. The

count spun was 24^s and in all cases the number of turns per inch was the same.

	Loss per cent. on cotton in blow-room.	Tension of 24^s warp.
American F. G. M. Boweds . .	7·75	57·44 lbs.
Panderkora Bani	·31	60·33 „
Lyallpur	10·08	52·20 „
Bhuri	10·37	46·10 „

The prices at the time of purchase of these respective varieties were very nearly the same in all cases, being about Rs. 130 per *boja* of 345 lbs. laid down at Nagpur.

On this basis, but including the blow-room loss, the purchase prices per lb. work out as follows :—

American	6·5 annas per lb.
Panderkora Bani . . .	6·53 „ „ „
Lyallpur	6·63 „ „ „
Bhuri	6·65 „ „ „

To conclude with the Punjab, it is necessary to add that Messrs. Tata, Sons & Co. and the Directors of the Bombay Cotton Trade Association have thus remarked on a set of samples submitted to them for opinion by the Economic Botanist : " Only two samples out of the 27, Nos. 161 and 179, can be compared with American. They are splendid cottons, especially in the length and strength of their fibres, and every help and encouragement should be given for their cultivation on an extensive scale. If the cultivation of these cottons turn out a commercial success it will finally solve the problem of obtaining long staple cotton from the British territory. We are afraid, however, that the dream is difficult of realization. The exotic has to contend with the soil and climate as well as with the apathy, indifference, ignorance and prejudice of the Indian cultivator."

The valuations of these samples in order of merit, by the Bombay Chamber of Commerce and Messrs. Tata, Sons & Co., Bombay, are appended. As the outturn and percentage figures are unknown to me it is impossible to say in the absence of these data which if any of them are the most

profitable to grow, and I hope that the Department in the Punjab will be able to furnish the figures necessary for comparison.

Valuation by the Bombay Chamber of Commerce.

BASIS.

Middling American at Rs. 340 per candy of 784 lbs. less 5½ per cent.
Fine M. G. Naosari „ 320 „ „ „ „ „
Good Tinnevelly „ 310 „ „ „ „ „
Fine M. G. Broach „ 290 „ „ „ „ „

All for ready delivery in Bombay.

Valuation by the Bombay Chamber of Commerce, dated the 13th May 1912, on the 27 samples of cotton from Lyallpur, Punjab.

Serial No. (according to merit).	Variety.	Approximate market value per candy of 784 lbs. on May 13th, 1912, less 5½ per cent.	REMARKS.
		Rs.	
1	161	425—450 (Nominal).	Superfine long silky staple. Impossible to give accurate valuation and sample should be sent to Liverpool.
2	280F	380 (Nominal).	Strict fine, long staple and good colour.
3	271	365 (Nominal).	Superfine, good long staple, good colour.
4	274	350 (Nominal).	Strict fine, long silky staple, good colour.
5	246	325	Superfine, long silky staple, good colour.
6	272	320	Strict fine, nice staple and colour.
7	273	320	Fine, rather better staple than 272.
8	72F	320	Superfine in class, long silky staple, good colour.
9	111	320	Strict fine, good staple and colour.
10	168	315	Strict fine, good strong staple.
11	112	312	Strict fine, good strong staple and colour.

Valuation by the Bombay Chamber of Commerce, dated the 13th May 1912, on the 27 samples of cotton from Lyallpur, Punjab. —contd.

Serial No. (according to merit).	Variety.	Approximate market value per candy of 784 lbs. on May 13th, 1912, less 5½ per cent.	Remarks.
		Rs.	
12	126	310	Superfine class, strong staple, good colour.
13	199	310	Superfine, strong staple but not very long, good colour.
14	7F	305	Strict fine in class, nice staple but not very silky, good colour.
15	110	300	Strict fine, good staple, and good colour.
16	267	300	Superfine, staple a little better than 266. Cotton is more bulky.
17	275	300	Strict fine, moderate staple, good colour but leafy.
18	70F	295	Strict fine in class, irregular and rather rough staple, good colour.
19	276	295	Fine, moderate staple, leafy.
20	220	290	About fine, staple strong but rather rough and irregular.
21	266	290	Strict fine, only moderate staple, nice colour.
22	233	280	Strict fine, fair staple but rather rough.
23	270	280	Fine fair staple.
24	226	275	Superfine, rough and short in staple, more like Rajputana cotton.
25	232	270	Fine, rather rough and short in staple, colour not so good as 226.
26	28D	265	Strict fine, poor staple and very wasty.
27	179	..	No sample sent.

Valuation by Messrs. Tata, Sons & Co., Bombay, dated 10th May 1912, on the 27 samples of cotton from Lyallpur, Punjab.

Serial No. (according to merit).	Variety.	Remarks.
1	179	Quite equal to Fully Good Middling American cotton. To-day's (10th July) price will be 8*d.* per lb.c. i. f. Bombay or say Rs. 425 per candy.
2	161	This cotton is far and away the best of its kind grown in Indian soil and acclimatized to the Indian climates. Though not exactly after the American style, it is no way inferior to Good Middling. The length of the fibre is fully $1\frac{1}{8}$ inch. Good Middling American of $1\frac{1}{8}$ inch staple cannot be laid down in Bombay under $7\frac{1}{2}$*d.* per lb. or say Rs. 365 per candy. If you add $5\frac{1}{2}$ per cent. discount allowed in Bombay the cost comes to Rs. 385 per candy. We value this cotton, therefore, at Rs. 385 per candy.
3	271	This cotton is exactly like Naosari in its feel and length of fibre. Value Rs. 340 per candy.
4	274	Equal to the very best Surat. Value Rs. 325 per candy.
5	72F	This has the characteristic and style of the best Surat and being slightly better than 7F in the length of fibre, we value it Rs. 5 more, *viz.*, Rs. 325 per candy.
6	7F	This cotton is of the Surat style. It has a long even fibre like Surat, and the colour and appearance are strikingly like it. It is lacking, however, in the soft silky feel of Surat cotton. We value it in price equal to the best Surat cotton namely, Rs. 320 per candy.
7	111	This is again the best Surat style of cotton equal to 7F. Value Rs. 320 per candy.
8	68	Best Surat style of cotton. Value Rs. 320 per candy.
9	246	Surat style of cotton. Value Rs. 320 per candy.
10	272	Surat style of cotton. Value Rs. 320 per candy.
11	112	It is same as 111, but a shade short in the length of fibre; therefore, we value it Rs. 5 less, say Rs. 315 per candy.
12	270	Surat style of cotton, but slightly shorter in fibre. Value Rs. 310 per candy.
13	273	Surat style of cotton but slightly inferior in staple. Value Rs. 310 per candy.

Valuation by Messrs. Tata, Sons & Co., Bombay, dated 10th May 1912, on the 27 samples of cotton from Lyallpur, Punjab. —contd.

Serial No. (according to merit).	Variety.	Remarks.
14	276	Broach style of cotton, but a little longer in fibre even than 275. Value Rs. 305 per candy.
15	275	Broach style of cotton, but being slightly longer in fibre than Broach, we value it at Rs. 300 per candy.
16	267	Same as 266 but slightly better in staple. Value Rs. 300 per candy.
17	126	It is midway between the best Broach and Surat. It approximates more to Broach and we value it Rs. 10 more than fine Broach, *viz.*, Rs. 295 per candy.
18	266	Equal to the best Broach cotton. Value Rs. 295 per candy.
19	199	Best Broach style of cotton. Value Rs. 290 per candy.
20	220	This cotton has the style of superior cottons of the Central Provinces, say Warora and Hinganghat. Value Rs. 290 per candy.
21	70F	This cotton has the appearance of the best Broach and the fibre is a shade longer than that of Broach. We value it, therefore, at Rs. 290 per candy, say Rs. 5 more than the price of Broach.
22	110	This cotton resembles the superior grade cottons such as Warora and Hinganghat grown in the Central Provinces. It is slightly dull in colour; therefore, we value it Rs. 5 lower than Warora, *viz.*, Rs. 285 per candy.
23	226	This is of the style of inferior cottons of the Central Provinces, such as Wardha and Nagpur. Value Rs. 285 per candy.
24	233	Wardha or Nagpur style of cotton of the Central Provinces. Value Rs. 285 per candy.
25	232	Best Berars style of cotton such as Yeotmal. Value Rs. 280 per candy.
26	28D	In colour and style like superior Berars, but the fibre is very short and weak; therefore, we value it at Rs. 275 per candy.
27	280F	No sample sent.

Prices fixed upon the following *basis*:—

Bombay candy weighs 784 lbs. The price of cotton in Bombay includes a rebate of 5½ per cent. For example if you purchase cotton, say, at Rs. 300 per candy, the seller allows you a rebate of 5½ per cent. so that the actual price of cotton is Rs. 283½ per candy. Therefore, the prices quoted are subject to a rebate of 5½ per cent.

American Good Middling . .	7½*d.* c. i. f.		
,, ,, ,, . .	Rs. 365	net per candy.	
Fine Naosari	340	per candy.	
,, Surat	320	,,	,,
,, Broach	285	,,	,,
,, Warora-Hinganghat (Central Provinces).	290	,,	,,
,, Wardha (Central Provinces)	285	,,	,,
,, Yeotmal (Berars) .	280	,,	,,
Good Tinnevelly . . .	320	,,	,,

United Provinces.—I visited these in October and toured in the company of Dr. A. E. Parr, the Deputy Director of the Northern Division.

I made the following notes on my inspection of the cottons on the Agricultural Experimental Station at Aligarh :—

(1) *Bhuri* (*G. hirsutum, variety*, originally from Chota-Nagpur). This has grown well, but the yield is low and last year it produced practically no crop. I pointed out to Dr. Parr that the species normally consists of a mixture of a productive and non-productive form, the latter predominating in his plots. If selection is continued by using the former type, he will soon possess a strain of high class cotton suitable for his Division in all respects.

(2) Mr. Leake's selection (white flowered cotton or *G. roseum*) yields well and is a moderately early cotton.

(3) Mr. Leake's selection (broad lobed white flowered cotton, var. *cutchica*) has produced at the rate of 12 maunds of seed cotton per acre and on the score of outturn alone is distinctly promising.

(4) *Kil* or Garo Hill cotton is more productive than the two last named, but our experience is that it deteriorates rapidly to the standard of local types.

(5) Yellow flowered *Neglectum*. This yields a cotton of better staple.

All the field experiments are on the white flowered or *Varhadi* type of cotton. As in other parts of India, owing to its hardiness, high produce and also high percentage of cotton to seed, it is rapidly becoming the favourite variety of the cultivators. Already Dr. Parr has 300 acres under this in seed farms and next year he hopes to increase their area to 3,000 acres. In price of crop it surpasses yellow flowered cotton by Rs. 12 to Rs. 15 per acre. There is little difference in the yield of broad cast and drilled plants. The best spacing distance has been found to be 18 inches between rows and 9 inches in the rows. A yield of 10 maunds of seed cotton per acre has been obtained. White flowered cotton grown with ground-nut yields about half the ordinary unmixed crop. The general practice is to grow cotton with *Cajanus indicus*. Dr. Parr says that in the Aligarh District about half the cotton crop is irrigated. Southwards the proportion of irrigated cotton decreases.

Mr. Graham, the Manager of West's Patent Press at Aligarh, thinks that, so far as cotton improvement is concerned, it would be sufficient to increase the outturn. He also thinks that a better staple should be arrived at. Few traders I have met seem to appreciate the fact that an increased staple in *Bengals* is invariably accompanied by a falling off in yield and percentage of cotton to seed.

After a discussion with Dr. Parr regarding his future line of work we agreed that the following would be most practicable :—

(1) To purify out the white flowered cottons and extend their cultivation as pure types. They have already been tested and proved to be more pro-

ductive and remunerative than the yellow flowered types.

(2) For the present we must conclude that American cotton has had a fair trial and has failed. In some cases it yielded badly and in others it could not meet with a suitable market.

(3) Dr. Parr will continue his experiments with the form of *Bhuri* that I have pointed out to him as being most suitable for the purpose.

(4) The experiments with yellow flowered *neglectums* should be persevered with. The staple is superior and it may prove remunerative to produce the cotton as a pure type. I showed Dr. Parr in the field how to readily distinguish the most productive plants of both white and yellow flowered cottons.

In company with Dr. Parr I visited Kashipur where a particular class of cotton was said to be grown. We found that the cotton was of exceptionally good quality, approaching in appearance and staple, the *Bani* or *Hinganghat*. I have advised Dr. Parr to make all his selections in the tract and not risk damaging the reputation of the local produce by bringing in anything from outside. I have since seen it mentioned in the newspapers that the Department is establishing a seed farm here.

The Tahsildar of Kashipur, Mr. Thakar Raghunathsingh, gave the following information. The rainfall of this tract averages between 40 and 50 inches. Last year it was 64 and this year 36. Last year the acreage under cotton was about 5,000 and this year 4,500. Wild animals from the reserved forests damage all crops excepting cotton. The average yield of seed cotton is 9 maunds per acre and under the most favourable conditions it reaches 12 maunds.

The price of Kashipur cotton is Rs. 2 per maund higher than that of ordinary *Bengals*.

The ginning factory proprietor at Kashipur is extremely anxious that no rough sort should be introduced to spoil the quality of the local fine variety.

I learnt that there are large areas of land suitable for cotton in Kashipur, especially near the reserved forest where the ravages of wild animals render the cultivation of grain crops so uncertain that these parts are relapsing into jungle. The quality of this cotton seems to be so excellent that (as I have already emphasized) all selection should be worked out on the spot and nothing in the way of *deshi* cottons should be introduced, whether they seem superior or not. There is a grand field here ready for growing selected local cottons and I am certain that Dr. Parr will not be slow in developing the possibilities of this tract. That two ginning factories have already been erected on the spot is proof positive of their owner's anticipation that the cultivation of cotton in this favoured tract will ultimately extend largely and rapidly. Personally, I was gratified to discover this tract as I was by then despairing of finding anything in the United Provinces better than ordinary *Bengals*.

The cotton grown round Chandausi is famed for its whiteness and staple. It is grown as a dry crop and sold at a higher price than ordinary *Bengals*.

There is only one variety or type of this known and it is decidedly inferior to Kashipur cotton.

Messrs. Ralli Brothers' agent here informed me that in a good year Chandausi cotton can be classed as Oomras, but that it is very inferior this year. He also considers that on the whole the United Provinces' cottons are inferior to those of Berar. The poorest qualities come from the westward (Beawar for example) and there is a gradual improvement to the eastward.

The United Provinces' cottons consist of the usual mixture of the types yielding *Bengals*, and at Aligarh Farm it can be seen that these types are easily separated.

It is to be regretted that the cultivation of American cottons has failed, but the Department should remember that there is an expressed demand for improved indigenous cottons from traders and manufacturers in the Province itself, which it should attempt to satisfy.

The following are the valuations kindly furnished by Messrs. Tata, Sons & Co., Bombay, on the 5 samples grown at the Agricultural Station, Aligarh, last year :—

Valuation of the samples from Aligarh Agricultural Station (valued on 18th January 1912).

Out of 5 samples, Nos. 1 to 5, sample No. 2 is the best of the lot in point of length of fibre and feel. We value it to-day at Rs. 265 per Bombay candy, or say Rs. 15 more than the price of Fine Bengal (F. Bengal Rs. 245).

No. 3 is slightly inferior to the above in length of staple, value Rs. 260.

Nos. 1, 4 and 5 are all alike and may be valued at Rs. 255.

The above cotton is harsh in feel like wool and resembles Assam cotton. It can be used in mixing with wool as Assam is on the continent, hence it has a special value of its own. This kind of cotton is generally 15 to 20 rupees higher in price than fine Bengal in normal times. We value Assam cotton to-day at Rs. 265 per Bombay candy.

Madras.—I have had no opportunity of visiting this Province during the year, but a letter from Mr. Couchman, Director of Agriculture, to the Board of Revenue, last year, fully explains the situation. From this it appears that in Tinnevelly, the *Karunganni* variety of cotton and in Nandyal the white seeded *Tellapathi* cotton have been proved by field experiments, supported by expert opinion from the mills, to be superior to the mixed field crops of cottons ordinarily grown in the Tinnevelly and Kurnool Districts. To extend the cultivation of these varieties seed farms were opened in Tinnevelly in 1908 to grow *Karunganni* on a large scale. In Kurnool a beginning was made last year with 35 acres of seed farm for growing pure *Tellapathi* seed.

The rapid increase of the area under *Karunganni* showed that the people were keeping the seed themselves. With a view, therefore, to extend the variety to new tracts, 43 seed depôts were opened, many of them in new tracts,

as the tracts in which some of the depôts were opened in previous years had now become pure *Karunganni* tracts.

Very gratifying evidence is now forthcoming to show the value of this crop to the cotton trade of the district. In two cases, new ginning factories have been opened by export firms, in localities where pure *Karunganni* has been introduced on account of the fine quality of cotton now obtainable there.

The large distribution of seed by the Department has made the Tuticorin Circle practically a pure *Karunganni* tract. Messrs. Volkart Brothers write :—"We have during the last few years noticed that a relatively very good cotton is received from places near Koilpatti, including the railway stations of Nalaturputtur, Kumarapuram and Kadambar. We have no hesitation in concluding that your experiment has been highly satisfactory in its results. The cotton from these places fetches a better price and is better liked by spinners both in Europe and the East than the bulk of Tinnevellies which are marketed further north at Virudupatti, etc."

Messrs. Ralli Brothers also state that there has been a marked improvement in the quality of Tinnevelly cotton during the last few years, especially in the Tuticorin Circle.

This independent evidence from the large buyers is most encouraging as it shows that an appreciable improvement can be effected in a short time to the whole crop of the tract by the methods worked out by the Department.

In the Northern Circle there was a keen demand for the farm seed which gives better crops than the seed available from the usual sources.

There is also a large demand for Cambodia seed, but this season there is a disquieting report to the effect that it has deteriorated in staple so that manufacturers cannot spin the usual counts from it. An enquiry into this matter has already been instituted.

Valuation of the 17 samples of cotton from Koilpatti (Madras) furnished by the Bombay Chamber of Commerce, on the 18th April 1912.

Serial No. (according to merit).	Description.	Approximate market value per candy of 784 lbs., less 5½ per cent. discount.	Approximate market value per candy of 784 lbs., less 5½ per cent. discount.	Remarks.
	Uppam Variety.	Local value.	Export value.	
		Rs.	Rs.	
1	Uppam—Ordinary field crop . .	283	283	These samples are all disappointing in so much as the staple is harsh and rather like Kajputana cotton (Bengals).
2	Pedigree Uppam	280	280	
3	Do.	280	280	
4	Uppam—Ordinary farm crop . .	280	280	Staple very harsh and short.
5	Pedigree Uppam . . .	275	275	Same remark as for Nos. 1, 2 and 3.
	Karunganni Variety.			
1	Pedigree Karunganni . . .	335	Export value nominal.	Nice style with long silky staple.
2	Do. do. . . .	335		Long silky staple and very good spinning cotton.
3	Do. do. . . .	330		Nice staple, good style.
4	Karunganni—Ordinary field crop .	330		Very good staple.
5	Do. do. .	325		Very good staple.
6	Pedigree Karunganni . . .	325		Long staple and good style.
7	Karunganni—Ordinary farm crop .	320		Good staple.
8	Do. Ordinary field crop .	315		Good staple.
9	Do. do. .	310		Very bright clean cotton, but staple not nearly as good as the others; rather short.
10	Pedigree Karunganni . . .	300		Nice style, good silky staple.
11	Do. do. . . .	295		Nice style, good staple.
12	Selected Karunganni . . .	280		Short staple.

The export valuations are rather nominal owing to the large supplies of Americans this year at reasonable rates

compared with Indian cotton. The demand from Europe is for lower priced cotton with fair staple.

	Rs.
Basis.—Fine M. G. Broach	290
Fine M. G. Naosari	330
Fine G. F. Tinnevelly	310
Fine M. G. Bengal (Rajputana) . .	265
Fine M. G. Akola	275

Valuation of 8 samples of cotton from Bellary (Madras), furnished by the Bombay Chamber of Commerce, on the 31st May 1912.

Serial No. (according to merit).	Historical Description.	Approximate market value per candy of 784 lbs., less 5½ per cent. discount on 29th May 1912.	Remarks.
		Rs.	
1	Kappas and Lint of No. 3. Grown at Bellary Farm this year. This is a selection made in 1906-07 from a sample of Broach seed obtained from Surat.	295	Strict fine in class too yellow in colour for Broach description, staple about equal to Broach and quite as silky. Colour of the kappas is white but the cotton has a yellow tinge.
2	Kappas and Lint of No. 41. These are single plant-selections from the local cotton made in 1908-09. Grown at Bellary Farm.	288	Better in staple than No. 21.
3	Kappas and Lint of No. 21. Grown at Hagari Farm. This is an inter-cross of the local cotton.	285	Class as good as No. 11 ; staple a good deal better.
4	Kappas and Lint of No. 5. Grown at Bellary Farm this year. This is a selection made in 1906-07 from Kumpta-seed.	280	Has not got the usual Kumpta characteristics, class strict fine, fair to good staple.
5	Kappas and Lint of No. 11. An inter-cross of the local cotton. Grown at Hagari. The selection was made in 1906-07.	278	Class rather lower than No. 10, but staple better.
6	Kappas and Lint of No. 10. An inter-cross of the local cotton. Grown at Hagari. The selection was made in 1906-07.	275	Brighter and whiter than No. 9, staple also better but irregular.
7	Kappas and Lint of No. 44. Single plant, selection made in 1908-09 from the local cotton. Grown at Bellary Farm.	275	Class strict fine, but staple not so good as Nos. 11, 21 and 41.
8	Kappas and Lint of No. 9. Grown on Bellary Farm. This is an inter-cross of the local cotton. The selection was made in 1906-07.	265	Disappointing in staple and decidedly inferior in style to the ordinary Westerns and has not the same bulk, but class much better.

	Rs.
Basis.—Tinnevelly	295
Fine M. G. Broach	280
Good M. G. Kumptas	285
„ „ Westerns	270

Mysore.—In the Mysore State preliminary steps have been taken to establish the cultivation of higher class cotton in non-cotton growing areas and we expect that valauble assistance will be renderd in this direction by the co-operation of the European planters.

North-West Frontier Province.—In consultation with Mr. Robertson Brown it has been arranged that he is to grow large plots of his cottons and that I shall visit his farm when the crops are ripe, to arrange, on the spot, the line of future work he should take in hand.

He gave the following information in a letter to the Inspector General of Agriculture (now the Agricultural Adviser to the Government of India) : "I have just visited a tract in the Peshawar District which is famous in the North-West Frontier Province as producing heavy crops of high class cotton. I was accompanied by the Revenue Assistant, who fixes revenue, etc., so my information is correct. I found that the *banias* in purchasing the crops pay for 6 maunds and take their chances of profit on the outturn beyond that weight. Good average cotton fields in the tract yield 16 maunds per acre and 20 maunds is occasionally produced. I have not seen such heavy outturns of cotton recorded as being produced elsewhere in India, and I am writing to you to find if equally good crops are yielded in any other part. The soil is deep red alluvium and the tract irrigated very sparingly and irregularly from the rich, muddy, Bara River."

Lalio cotton, in the Bawla Taluka, in the Ahmedabad District, under two or three waterings in light soils, is said to yield as high as 1,600 lbs. *kapas* per acre, but the high returns quoted by Mr. Robertson Brown, so far as I know, must be unequalled elsewhere in India.

The following report on a sample of Mr. Robertson Brown's cotton has been received from Messrs. Tata, Sons & Co. :—

> "In all its characteristics it is Oomra style of cotton. Comparing it with Fine Akola ginned at Rs. 275 we value the sample at Rs. 270 as it

is slightly shorter in fibre. We quote Sind Punjab cotton to-day at Rs. 270. Though the sample is from the North-West Frontier Province it cannot be compared with Sind Punjab as the latter is whiter in colour but short in staple and coarse to the feel. The sample examined is of a dull white colour like Akola, the staple is longer than that of Sind Punjab and has better feel."

Experiments with Bhuri cotton on the Khetri Estate in Rajputana.—The seed was given by me for experiment to the Munsarim of this estate who has been courteous enough to furnish a report of his results. I may mention that such thoughtfulness is rare amongst my numerous correspondents. Two and half seers of seed were sown in an acre of land, the plants were spaced $1\frac{1}{2}$ foot apart and the land was watered four times before the rains and twice after the rains. The area consisted of garden land of the first class and the cotton finally collected weighed $2\frac{3}{4}$ maunds.

Messrs. Tata, Sons & Co. kindly furnished the following valuation on a sample of the cotton submitted to them :—

"*Bhuri.*—This cotton has vastly improved and is better than the best cotton grown in India, *viz.*, Naosari. The fibre is very long and is stronger than that of Naosari cotton. On the basis of Naosari at Rs. 335 we value it at Rs. 350 or fully Rs. 15 more per candy."

Arrangements are being made for a more extended trial with *bhuri* in the same locality during the present season. Rajputana appears to offer strong inducements for the production of higher class cottons, but it is difficult to get into touch with its people. I have reason to believe, however, that there is a spontaneous introduction of *bhuri* cotton into the States from Berar.

Bombay.—The following are some of the definite conclusions which have been arrived at in this Presidency :—

At Surat it has been decided to make a reduction in the number of varieties so as to simplify the work, and to discontinue the cultivation of tree cottons as not one has given a useful result.

At the Ganeshkhind Botanical Garden it has been proved that Bourbon only lasts for 6 years which is far short of the 20 years of life claimed for it.

At Dhulia it has been found that the white-flowered *Varhadi* excels in yield and ginning percentage. It has produced 1,500 lbs. of seed cotton per acre, of a value of over Rs. 200. Comparing price and outturn it easily outstrips in value all other Khandesh or Berar cottons. *Karkeli*, although of very high quality, does not yield sufficiently well to be remunerative.

At Dharwar, Cambodia cotton has not continued to be immune from red leaf blight. Mr. Main has arrived at the following conclusions regarding it :—

(1) Cambodia cotton can be grown most profitably in the early part of July in spite of the liability of early sown cottons to red leaf blight.

(2) The early sown crop begins to flower about the middle of November, but these flowers drop off and bolls do not set till December-January.

Bhuri again did badly. It suffered from the red leaf blight believed to be the disease known as the Mosaic in the United States of America. It appears to be less suitable than Cambodia for the conditions obtaining at Dharwar.

At the Gadag Farm, Cambodia Cotton has been proved to be the most suitable substitute for Dharwar American cotton in the eastern part of the Dharwar District, as it surpasses it in yield and ginning percentage.

The trials with numerous American cottons show that they all require considerable acclimatization. Mr. Main also finds that the green fuzz of the seeds of certain Dharwar American plants is not a fixed character as a number of white fuzz seeded plants are produced from green fuzzed

seed. On the other hand, white fuzzed seed appears to be a fixed character and such seed breeds true. These facts lead him to suppose that the colour of the fuzz may be a character which conforms to Mendelian laws. Experiments are still being persevered with towards the introduction of cotton into areas of land, lying waste partly owing to the damage liable to be caused by wild pigs. It is observed that cotton is not touched by these animals.

It is gratifying that the demand for Naosari and Cambodia cotton seeds is steadily increasing in the Karnatic. During the year under report both these cottons maintained higher ginning percentages and at the auction sale realized as in previous years more encouraging prices than the local Kumpta and Dharwar American as shown in the statement below :—

Variety.	Ginning percentage.	Value per naga of 1,344 lbs.
Broach (from Naosari seed) .	33	Between Rs. 170 and Rs. 203 according to grades.
Kumpta	27	Rs. 140.
Cambodia	37	Between Rs. 188 and Rs. 206 according to grades.
Dharwar American . .	30	Between Rs. 140 and Rs. 145.

At Mirpurkhas in Sind, the highest yield of Sindhi cotton was 1,304 lbs. per acre, the second best was at the rate of 960 lbs. per acre. This is compared with 1,683 lbs. seed cotton obtained in the previous year and with 1,280 lbs. in 1907. The best results have always been obtained from April sowings of cotton.

Some valuations by Messrs. Tata, Sons & Co. of cottons grown on the Agricultural College Farm, Poona, are interesting as they demonstrate two points : first, the influence of an unsuitable environment on cottons which require a better

soil and climate, and second, the ease with which the different types of "Bengals" can be separated.

No. 1. *Broach.*—From seed imported from Naosari in 1911. "This cotton grown from Naosari seed on Kirkee Farm is not exactly like Naosari cotton. It is decidedly superior to Broach and is equal to Surat cotton. Value Rs. 310 (Naosari at Rs. 330 per candy)."

No. 2. *Varhadi.*—Seed obtained from Akola in 1911. "This cotton is equal to short stapled Oomra. Value Rs. 255."

No. 3. *Bhuri.*—Seed obtained from Akola in 1911. "This cotton is superior to No. 1, and we class it as best Naosari. Value Rs. 330."

No. 4. *Cambodia.*—Seed obtained from Gadag in 1911. "This cotton is equal to best Surat. Value Rs. 320."

In Nos. 5, 6, 7 and 8, the seed was obtained from Akola five years ago and was sown just as it was. The types were separated out on the farm from this mixture and grown separately in succeeding years.

No. 5.—(Yellow flowered, broad lobed *neglectum*, from Dhulia mixture.)—"Dhulia seed gives improved cotton in Kirkee soil. It has produced cotton equal to Ghat Akola, good staple. Value Rs. 285."

No. 6.—(Yellow flowered, narrow lobed, from the same mixture.)—"Slightly inferior to No. 5. Value Rs. 280."

No. 7.—(White flowered, broad lobed, from the same mixture.)—"This cotton equals the lowest grade Khandesh and is very poor in staple. Value Rs. 245."

No. 8.—(White flowered, narrow lobed, from the same mixture.)—"This cotton equals ordinary Khandesh, and is very poor in staple. Value Rs. 255."

Basis of valuation on 10th July 1912 :—

	Rs.	
Naosari	330	per candy.
Surat	310	,,
Broach	290	,,
Akola	275	,,
Khandesh	265	,,

Judging from the valuations received from Messrs. Tata, Sons & Co., the Kumpta cotton from the Sangli State in the Southern Mahratta Country fetches a higher price than that of the same country to the southward. There are presumably highly favourable conditions of soil and climate in this State and the Department of Agriculture, Bombay, may see its way to investigate the possibilities of this tract as a seed distributing centre of Kumpta cotton.

The suspicions of Messrs. Tata, Sons, that the labelling of the bags was transposed, is not confirmed.

The Agricultural Superintendent of the State had grown Broach from seed imported from Naosari and the Kumpta was from an *inter se* cross.

The following are Messrs. Tata's valuations and remarks (on 11th March 1912) :—

"*Sample No. 1.*—Broach cotton grown at Sangli from the seeds imported from Naosari. The cotton shows much improvement, both in colour and staple. Though a slight tinge of red can be detected, the colour is more than fine. On the basis of Rs. 330 for Naosari cotton, we value this at Rs. 340 per candy.

"*Sample No. 2.*—Local (Kumpta) cotton crossed *inter se*. This is really a beautiful cotton, soft and silky in feel with a strong and even fibre, equal to, if not better than, Naosari cotton in length. It is more like indigenous Naosari cotton than like Kumpta. In fact we were in doubt whether a mistake had not been made in bagging the samples. It is really better than No. 1 in all respects and we value it at Rs. 20 over No. 1, *viz.*, Rs. 360 per candy.

> "The Sangli soil appears to be eminently suited to the growth of Kumpta cotton, crossed *inter se*, and it is worth experimenting with on a large scale."

The Native States of Palitana and Rajkot in Kathiawar have been supplied with cotton seeds of varieties at their request and the results will be watched with interest.

Valuations.—All samples received were submitted to Messrs. Tata, Sons & Co., Bombay, for valuation; and cordial acknowledgment is due to them for their kindness and promptitude in giving opinions on cottons whenever submitted to them.

A few samples were also submitted to the Bombay Chamber of Commerce to whom thanks are also due.

Programme of work for 1912-13.

It is proposed to tour in the North-West Frontier Province in the autumn to advise on the possibilities of improvement of cultivation and introduction of suitable superior varieties. Tours will also be made in the Bombay Presidency and the Central Provinces and to other parts also, if my services are called for to continue the investigation into the conditions which affect the production of cotton. This enquiry is also carried on wherever touring is done.

In addition I shall continue my special researches in the botany and cultivation of cotton.

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