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# THE INFLUENCE OF BACTERIA UPON SOIL FERTILITY.

By C. M. HUTCHINSON, B.A.,

*Imperial Agricultural Bacteriologist.*

Previous to the introduction of the science of soil bacteriology the laboratory examination of soils had been mainly directed to the discovery of the causes of their relative fertility by methods depending upon the determination of their chemical and physical constitution. Chemical analysis has told us much as to the plant foods present or wanting in soils, and has suggested the use of artificial and other manures in the field; mechanical analysis has shewn the necessity for taking into consideration the texture of the soil as a prime factor in producing fertility, but neither of these methods can provide full information as to the multitudinous and complex changes going on in the soil, the sum of which results in the production of available plant food. The importance of the biological factor has been more fully realized in recent years, and the object of this paper is to give an outline of the methods which may be adopted for determining the constitution of the soil complex and its relation to fertility.

The point to be kept in view is not so much the mere making of a biological analysis of a soil as the determination of its response to cultivation, to irrigation or drainage, or to application of manures, whether organic or otherwise, such determination being based upon the following considerations. A normal soil contains bacteria which may be roughly divided into two classes so far as fertility is concerned (1) beneficial, (2) detrimental. Fortunately the beneficial kinds predominate in the large majority of cases, and for our purpose it will be sufficient to indicate the part they play in producing fertility

The beneficial bacteria may be sub-divided according to their functions in the soil :—

(1) Those which attack organic matter or soil humus and convert its nitrogen into ammonium compounds.

(2) Those which produce nitrites from these ammonium compounds, and those which further oxidize the nitrites to form nitrates.

(3) Those which bring atmospheric nitrogen into combination as organic compounds, thus increasing the supply of this element in the soil.

(4) Those which attack and break down organic matter in the soil but do not necessarily produce ammonium compounds, their action being beneficial as resulting in the disintegration of vegetable tissues which are consequently more readily attacked by ammonifiers.

Now the presence of these various classes of micro-organisms in any sample of soil may be determined by appropriate methods which allow of their separation and identification, and even of calculation of their numbers, so that it might be supposed that by the use of such analytical processes definite information as to the relative fertilities of soils might be obtained so far as their bacterial content was concerned. Now this is unfortunately an impracticable method, not only on account of the extremely tedious and laborious work involved, but also because of the impossibility of integrating the individual results with any probability of arriving at a true statement of their sum. Other simpler and more reliable methods are therefore utilized to determine the biologic activity of a soil, and I hope to show not only how this is measured directly, but by what means an estimate may be obtained in the laboratory of the probable value of various agricultural operations when applied to the soils under examination.

As pointed out above, the object to be kept in view is the response of the soil to various agricultural operations, and it would be well to formulate these in conjunction with their effect upon the condition of the soil and the probable modifications in the bacterial content resulting therefrom.

### 1.—Tillage Resulting in Increased Aeration.

The activity of practically all beneficial bacteria is increased by this means: the breaking down of vegetable tissues such as roots, stubble, green manures ploughed in, and cattle manure is dependent upon sufficient aëration of the soil, and so, to an even more marked extent, is the final process of nitrification.

### 2. Irrigation and Drainage.

These two complementary procedures are intended to regulate the water content of the soil, primarily for the supply of moisture to crops, but the maintenance of the optimum amount of water is also vital to the action of beneficial bacteria: shortage of water produces cessation of their activity, and excess, or water-logging, not only has the same result but encourages the action of certain detrimentals, notably those denitrifiers which are responsible for the losses of combined nitrogen which take place under these conditions: aeration is also dependent upon a proper regulation of the water-supply.

### 3.—Manuring.

Although all cultivated soils contain bacteria, the number of these which are found varies enormously in accordance with certain factors such as water-supply and temperature, but also in proportion to the amount of organic matter present, so long as this is not in any great excess. The correlation between number of bacteria and percentage of humus is one that necessarily suggests itself, just as it is natural to assume that the most fertile soil is, *cæteris paribus*, that one containing the optimum amount of this constituent. The addition therefore of organic manures to any soil will affect the numbers and activities of the soil organisms in proportion to the resulting approximation to the optimum humus content; that is to say, that we may expect to find not only an increase in the number of bacteria but a proportionate rise in the degree of biologic activity on addition of organic matter such as oil cake or green manure to a soil which previously contained less than the optimum amount. In the present state of our knowledge of the subject we are not able to make any very accurate use of this method of determining the reaction of a soil to such treatment, but further study of the complex factors involved will no doubt increase our knowledge of the relation between humus content and fertility. Such study must include observations not only of the numbers of bacteria associated with varying contents of humus, but of the effects of such variation upon the relative numbers of the different kinds of micro-organisms, and upon the total resulting changes in the condition of the plant food which depend upon their activity. The effect of the addition of vegetable matter to a soil may be considered under three heads: (1) as directly adding nitrogen in the form of nitrogenous plant tissue; (2) as stimulating the action of nitrifiers; (3) as encouraging the growth of nitrogen fixing organisms such as Azotobacter, which, if supplied with carbohydrates, such as sugars, can take up free atmospheric nitrogen which is thus added to the store of this element in the soil.

Under the first two heads come green manures, roots and stubble and weeds either growing with the crop or ploughed in after fallowing; under the third head we find comparatively few instances in actual practice and the result of their application is only doubtfully to be assigned to the fixation of atmospheric nitrogen. The use of molasses in Mauritius on sugar-cane soil may no doubt depend for its efficacy upon such action, and it appears probable that certain artificial cultures ostensibly purporting to convey root nodule organisms into the soil mainly affect the nitrogen content of the latter through the agency of nitrogen fixers such as Clostridium, which do not enter into symbiotic relationship with leguminous plants. I do not propose to deal with this aspect of soil fertility, and shall therefore omit any special reference to the reaction of soils to treatment calculated to encourage the growth and activity of Azotobacter or similar nitrogen fixers.

The problems involved in the management of the operation of green manuring will naturally resolve themselves into a series of investigations as to the effect of this process upon the biologic condition of the soil. The point of growth at which the green crop may be ploughed in with the best results, and whether this should be done directly, or after cutting and drying; the effect of adding lime or gypsum to the soil at the time of ploughing in and of the distribution of the rainfall, all these points are evidently so closely connected with the biological factor as to demand exhaustive biological analysis, which alone can give any satisfactory indication of the best method of dealing with such questions.

Similarly in the case of cattle manure, the information provided by chemical analysis as to the amount of plant food introduced into the soil in this form will give but meagre indications of its real relation to fertility. It is necessary to take into account not only the amount of plant food in the manure and the specific effect of the latter upon tilth, but also the capacity of the soil to deal with it successfully through the agency of bacteria, which depends not only upon the presence of the latter in sufficient numbers but also upon a proper supply of water and air, secured only by the amenability of the soil itself to tillage. Furthermore, it is of no less importance to consider the effect of the cattle manure as a conveyor of bacteria into the soil, but the complexity of this aspect of its functions as a fertilizer makes it inadvisable to deal further with it at present.

The relationship between bacterial activity and manuring with artificials, such as superphosphate, potash and lime, has not so far been studied very closely, except in the case of nitrification. Here a very intimate relationship has been shewn to exist between the amount of nitrification effected and the presence of lime; and the same has been found to a lesser degree to be the case with phosphates and potash. The action of sulphate of ammonia upon the soil in producing an acid condition of the latter must be taken into account as influencing its bacterial activity, and the effect produced by certain potash manures upon the texture of the soil has similar results. Fallowing and the rotation of crops must also of necessity affect the constitution of the soil complex and depend largely for their effect upon this action.

It will be seen, therefore, that the success of every agricultural operation, designed to increase the fertility of the soil depends very largely upon its effect upon the activities of soil bacteria, although these methods of treatment have been arrived at empirically and without any knowledge of this relationship. The evolution of many other arts requiring the intervention of micro-organisms has depended upon similar empirical methods, such as those which were in use in distilling, brewing, dairying and vinegar making, until comparatively recent times. The great improvements effected in such industries by scientific study of the organisms involved, gives us good reason to expect that the science of soil bacteriology, at present in its infancy, will in its turn do for agriculture what similar methods of research have done for these other arts.

## Laboratory Methods.

The following description of the methods in use in the laboratory to determine the reaction of soils to the various agricultural operations described above, is not intended as a guide for laboratory use, but merely to give an indication of their scope, and may perhaps afford some further insight into the possibilities and limitations of soil bacteriology. It will be seen from this description that our knowledge of the changes produced by bacterial action depends upon (1) observation of the actual growth of bacteria, and cultural methods adopted for their separation, identification, and enumeration, and (2) chemical analysis designed to ascertain the results of bacterial activity in artificial culture media and in soil samples.

Culture media are designed to promote the growth of micro-organisms and are either intended to allow of the development of all organisms, present in the soil sample within wide limits, or have a special constitution which will favour the growth of certain bacteria whilst preventing that of others which may be present. Media may be either solid or liquid, the former class including such media as gelatine and agar and the latter such solutions as beef broth, peptone solution, and special solutions containing the elements essential for growth, but characterized by the presence of certain inorganic salts or organic compounds, which serve either to promote the growth of certain bacteria if present, or to indicate their power to produce certain special chemical changes. As an example of the former may be instanced the special solution containing mannitol or mannite which promotes the growth and nitrogen fixing activity of Azotobacter, and of the latter class an example is afforded by nutrient solutions containing, in addition to the necessary elements, sulphate of ammonia, the oxidation of which to nitric acid may be measured, and the amount of the latter formed taken as an indication of the presence and activity in the soil sample of nitrifying organisms. The solid media gelatine and agar owe much of their usefulness to the fact that they may be liquefied by heat, and in this condition inoculated with the soil extract containing the bacteria whose characters it is desired to determine. In the description of the operation of plating which follows, the value of this property will be shewn and indeed it may be said that bacteriology has made its greatest advances as a science as a direct consequence of the introduction of this method by Koch. It would be impossible within the limits of this paper to give any further account of the numerous media which are employed in soil analysis; but it is hoped that the description of the special methods which follows will give some idea of the bearing of their composition upon their utility in determining the presence and general character of soil bacteria.

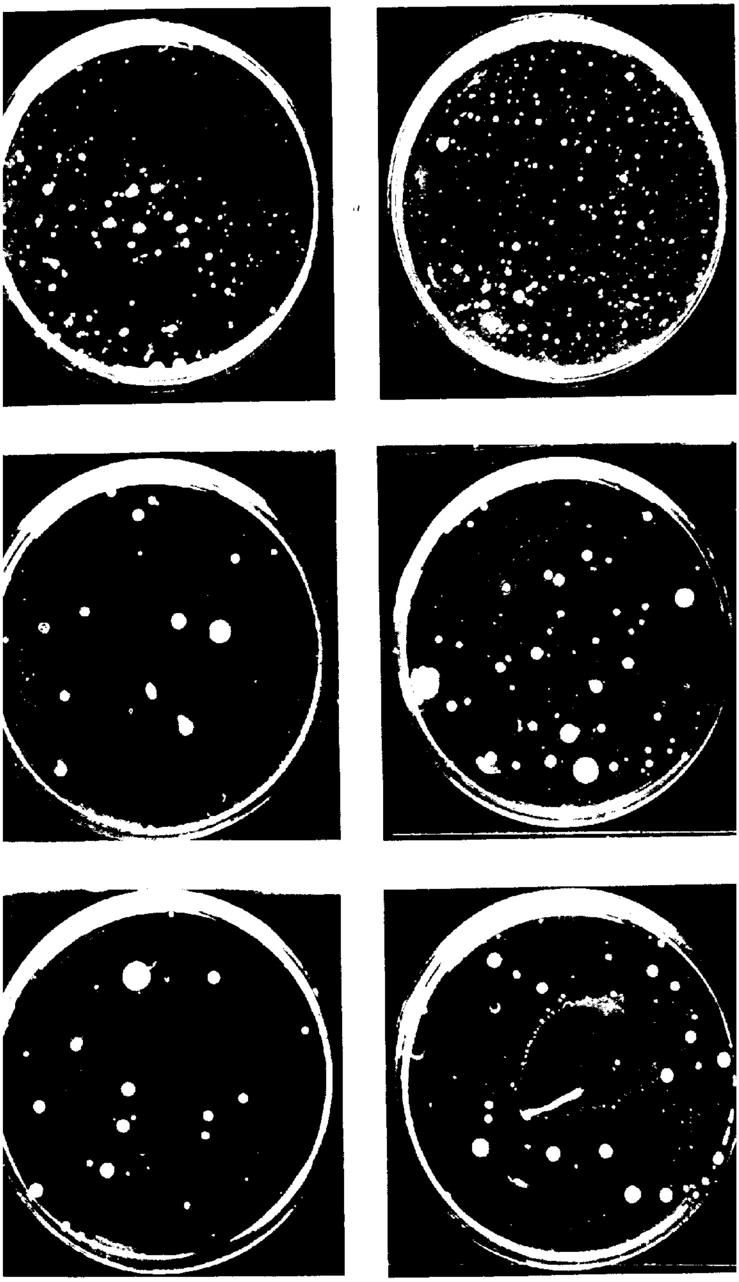
## PLATING.

A weighed quantity of the soil to be examined is shaken up with sterile water and a small portion of the extract thus obtained introduced into a test tube containing the medium, either gelatine or agar, the latter having been previously liquefied by heat, and kept at a temperature sufficiently high to ensure fluidity but not high enough to kill the bacteria. The liquid medium is then stirred to distribute the bacteria evenly throughout it, and is poured out into a flat glass dish with a loose cover (a Petri dish) and allowed to set by cooling, after which it is kept in an incubator at a constant temperature. After 12, 18, or 24 hours, bacterial growths will be found forming "colonies" upon or under the surface of the medium. The dilution with water referred to above is made use of in order to reduce the number of bacteria present to an amount which will allow of the separation of the individual bacteria from one another by sufficient distances to prevent over-crowding of the plate with colonies; each colony is produced by reproduction from a single bacterium, and it is this fact, together with the solidity of the medium, which prevents the bacteria contained in it from moving about, which makes it possible to obtain pure cultures, that is, cultures containing only one kind of bacterium, by this method, if the dilution is sufficient to separate the individual colonies from one another.

Plate XIX reproduces photographs of soil plates prepared in this manner, shewing the varying numbers of colonies obtained from poor and rich soils, and from different depths in the same soil. It is from such plates that counts are made of the numbers of bacteria actually present in the same weights of various soils, and indications obtained of the variation produced by different methods of treatment, such as partial sterilization by heat or antiseptics. In Plates XX and XXI are shewn the action of hot air, steam, drying at 50° C. and various antiseptics, in reducing the normal number of colonies. Such plates are of use in determining the value of various methods of sterilizing soil samples, this last being a necessary preliminary to many laboratory methods of investigation, but are reproduced here mainly on account of their interest in connection with recent theories of soil fertilization by partial sterilization. I do not propose to consider these theories at present, but I have introduced the plates in question as of general interest in connection with the subject of plating, and of particular interest as illustrating the effect of hot weather ploughing or "weathering" upon the bacterial content of Pusa soil.

Although it is impossible in a photograph to do much more than shew numerical variation, it will be easily understood that

PLATE XIX



POOR SOIL. RICH SOIL.

DILUTION 1 IN 100,000.

examination of the plates themselves reveals differences of a much more complex order. Thus, after heating a soil for three days to a temperature of 60 C., although no great difference in number of colonies may result, yet a very obvious alteration in their character is generally apparent. It must be understood that the kind of growth, or "cultural character," which is formed by a bacterium is a more certain means of recognizing its species than is its form as seen under the microscope; bacteria which appear similar so far as their form is concerned, presenting easily recognized differences when grown on various media.

These "cultural characters" include variation in the form and colour of the "colonies," and differences of behaviour towards the medium, such as are presented by liquefaction of gelatine media or the production of acid and gas in those containing sugar. On these lines a complete analytical scheme is made use of, resembling those adopted in chemical practice, in which the various culture media take the place of chemical reagents, being utilized to distinguish between species of bacteria by the differences in the reaction of the latter to the media on which they are cultivated.

Having obtained information by plating as to the numbers and species of bacteria present in the soil under examination, further investigation is aimed at determining its capacity for producing plant food from organic matter by ammonification and nitrification. As an introduction to the description of the analytical methods employed to determine the extent to which these two processes can be carried in any particular soil, it is necessary to draw attention to the distinction which must be made between the power of a soil to produce nitrification, depending upon the numbers and activity of nitrifying organisms it contains, and its capacity for nitrifying organic matters introduced into it, which depends indeed upon the activity of the bacteria, but still more so upon the physical condition of the soil itself with regard to water-supply and aëration. It is for this reason that special methods of ascertaining the nitrifying capacity of a soil are made use of, involving recognition of this fact, and intended to determine not only the nitrifying capacity of the soil, but under what conditions of water content, aëration, humus content or supply of such substances as lime, phosphates or potash, the most favourable results may be obtained. This has been referred to above as a method of determining in the laboratory the reaction of a soil to treatment in the field: and it is hoped that a description of the method will provide some indication of the value of soil bacteriology as an aid to elucidating the primal problem of fertility and its causes.

### NITRIFICATION.

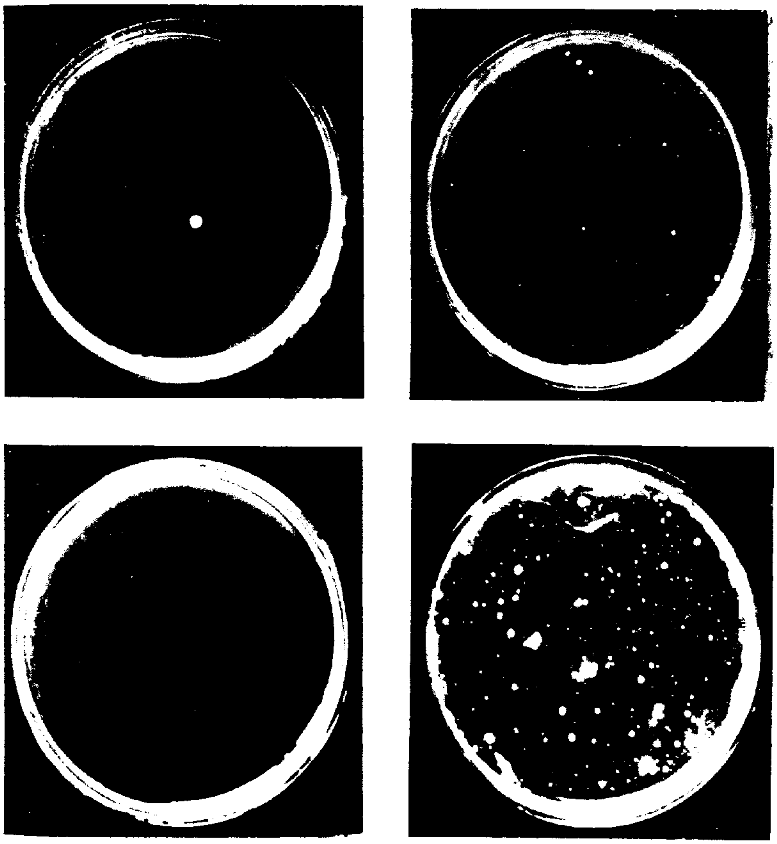
This process is so intimately connected with the provision of available nitrogenous plant food, that the nitrifying power of a soil may be considered as a limiting factor in fertility. The primary object of the laboratory examination of soil samples is not, however, the mere measurement of their relative nitrifying powers alone, but is intended to discover (1) what nitrifying power they possess, and (2) under what conditions this may be made the most of. Remembering that "nitrification" means generally the conversion by bacteria of organic nitrogen, which, in the form in which it exists in vegetable matter is not available as plant food, into nitrates, which are readily assimilable by crops, our aim is to discover the capacity of a soil to produce this effect upon addition to it of organic matter such as green manures, cattle manure or oil-cake. A special case is the oxidation of sulphate of ammonia when used as a manure and this reaction may also be measured in the laboratory.

Two alternative methods can be adopted for estimating the nitrifying power of a soil: a weighed quantity of the soil sample may be introduced into a liquid medium containing sulphate of ammonia in addition to the necessary nutrient salts, or a measured volume of a watery extract of the soil may be poured over a sterilized portion of the same soil, to which a known quantity of nitrogenous matter has been added. In either case periodical analyses are made, of the solution in the first method, and of the soil medium in the second, to determine the amounts of nitrite and

## PLATE XX.

Hot Air.
150 C. ½ hour.

Steam Sterilizer.
1 hour 100 C.



A. J. L.

Autoclave. 2 days
130 C. ½ hour.

Exposed to Sun.
50°, 6 days.

nitrate which have been formed. It has been found that the first method, originally proposed by Oméliansky and others, does not give certain indications of the nitrifying power of a soil owing to the lack of aëration in the liquid medium, and the want of approximation to those natural conditions which obtain in the soil itself. The laboratory measurement of nitrification at Pusa is therefore made by the second method, although this involves the use of larger soil samples and is generally more laborious.

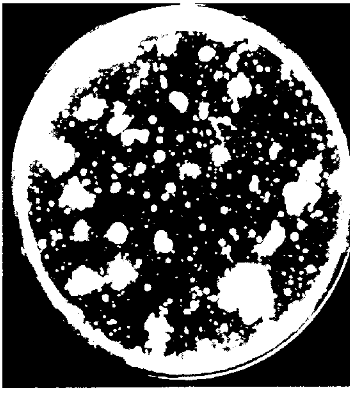
By this method it is possible to measure approximately the amount of nitrate produced in various soils from organic matter added in the form of (1) green manure, (2) oil-cake, (3) cattle manure, (4) crop residues such as straw, stubble, roots, etc., (5) sulphate of ammonia used as artificial manure. Further valuable indications may be obtained as to the effect upon nitrification of various agricultural operations: thus the optimum amount of water for nitrification in the particular soil under examination may be determined by varying the amount added to the soil medium; the effect of cultivation with consequent aëration may be observed by periodical stirring of the soil medium, and also the result of adding lime and artificials such as potash and superphosphate. In many cases in actual practice the fertility of a soil has been found to be prejudicially affected by the use of certain manures and in other instances their addition has not resulted in the expected increase of crop. Determination of the effect upon the nitrifying power of the soil of such manures may shew that their failure is due to their relation to this factor in fertility, and may indicate a variation in treatment in the field accordingly. Thus the successful use of sulphate of potash for a crop requiring potash to produce a full return might depend upon its application at such a time of year as would not interfere with the activity of the nitrifying organisms and the consequent supply of nitrates for the crop, or again, more complete information as to the nitrifying processes in a soil obtained by laboratory examination might indicate the advisability of ploughing in a green manure at a particular stage of its growth coincident with a certain water content of the soil or with a condition of the plant itself favourable to attack by those micro-organisms responsible for the initial stages of its decay.

### AMMONIFICATION.

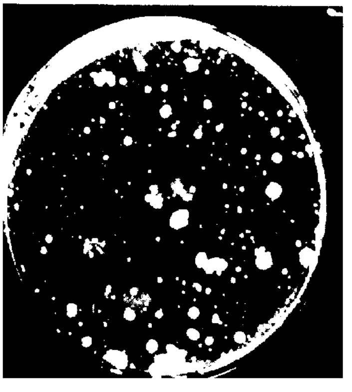
Before nitrification can take place in a soil the nitrogen contained in its humus must be converted into ammonium salts; this change depends upon the presence and activity of micro-organisms either bacteria or fungi, many species of which may be classed as ammonifiers in consequence of their power to produce ammonia from nitrogenous organic matter. The ability of a soil to deal successfully with organic matter will therefore depend upon the presence therein of ammonifiers and the general suitability of the soil itself as a medium for their growth and activity. Observations may be made in the laboratory on simialr lines to those described above in connection with nitrification, to determine the ammonifying power of a soil sample. For this purpose a weighed quantity of the soil is introduced into a solution containing peptone, a soluble form of nitrogenous organic matter, periodic determinations of the ammonia formed being made. Further and more useful information as to the ammonifying capacity of a soil may be obtained by the use of the soil itself as a medium, as described above in the case of nitrification, and in actual practice parallel determinations of the ammonia and nitrates produced are carried out in duplicate samples. If it is wished to determine the suitability of the soil under examination for the growth and activity of ammonifying organisms, a sterilized sample may be inoculated with a pure culture of such a bacterium as Bacillus Mycoides, after admixture with a measured quantity of some such organic nitrogenous substance as oil-cake, the rate of production of ammonia affording an indication of the condition of the soil with regard to bacterial growth and action. In this case again, information as to the reaction of the soil to treatment in the field may be obtained by modification of the water content, addition of organic or mineral manures or of lime salts, and further problems as to the effect of water logging, of compacting the soil, and of ploughing in the

# PLATE XXI

Toluene 5%.
3 days.



Control. Untreated.



Thymol Saturated.
5 Solution.

Formaldehyde Vapour.
24 hours.

hot weather or in the rains, may be studied from the biological point of view.

Recent work on soil bacteriology at Rothamsted has demonstrated the intimate connection between the presence of ammonifiers and fertility: it has been shewn that plants can assimilate nitrogen in the form of ammonia without its conversion into nitrates, and it has further been proved that the increase in fertility produced by partial sterilization of a soil is directly connected with the corresponding increase in the number of ammonifiers. Partial sterilization may be effected by a moderate degree of heat (98°C.) or by the use of antiseptics such as toluene; the immediate result of such treatment is the destruction of all actively growing (vegetative) micro-organisms, and plating shews a corresponding diminution in the number of colonies, but further plates made after an interval of some days shew by their numerous colonies that some forms of life have survived the sterilizing treatment and have subsequently multiplied in the soil. This survival is limited to those forms which can produce spores as a method of reproduction, these spores being particularly resistant to the action of heat and antiseptics, enabling the organism to withstand high temperatures, as in the case of Bacillus Subtilis, the so-called Hay Bacillus, the spores of which survive boiling in water for as much as an hour without losing their vitality. It has long been known that partial sterilization produces increased fertility, but this has been generally considered to be due to alteration in the chemical content or physical texture of the soil. The Rothamsted experiments give good reason to suppose that such increase is mainly due to the destruction by the heat or antiseptics of all living soil organisms except those existing as spores, thus removing from the soil those protozoa (ciliata and amoebae) which prey upon and keep down the ammonifying bacteria. Upon the removal of the antiseptic, or return of the soil to its normal temperature, the surviving spores germinate, and the bacteria, unchecked by the predatory protozoa, multiply rapidly, giving rise to a corresponding increase in ammonia production and consequent supplies of available nitrogenous plant food. This view has a special interest in India, as it appears to indicate a possible cause for the increased fertility produced by hot weather ploughing. Mr. Howard of Pusa, who uses the term "weathering" for this operation, is of opinion that partial sterilization is effected by the high temperature, about 60°C. to which the surface soil is raised under the hot sun of April, May and June. I have found that this temperature actually produces an alteration in the bacterial content of the soil, and if it penetrated to the lower layers it would no doubt eliminate many of those bacteria which produce unfavourable soil conditions such as result from the elaboration of organic acids, such as butyric acid from humus. The actual results of "weathering," so far as I have been able to ascertain them in the laboratory, are as follows:

*First.*—More or less complete desiccation of the soil resulting in the death of most protozoa and many bacteria.

*Second.*—Complete aeration, producing conditions highly favourable to nitrification and preventing acid fermentation of humus.

The alteration of the physical texture of the soil and all the effects associated with proper tilth do not come within the scope of this paper, but it will be readily realized that they must play an important part in the preparation of the soil for cultivation of crops. Mr. Howard has described elsewhere the increased fertility due to this method and has emphasized the obvious increase of available nitrogenous food to be inferred from the general appearance of the crops raised on "weathered" soil. Further investigation is being carried out of the causes underlying this result, and it is hoped that some useful information may be obtained by bacteriological analysis.

Certain bacteria develop more rapidly under conditions which prevent free access of oxygen: these are known collectively as anaërobes and include many of those bacteria which are responsible for detrimental reactions in the soil such as denitrification and acid fermentation. Denitrification implies the reversal of the beneficial process of nitrification, the result being the reduction of nitrates to nitrogen gas, which then escapes as such into the air and is lost to the agriculturist. Fortunately it is possible to avoid much of this loss by methods of cultivation which ensure proper aëration of the soil ; tillage and draining effect this purpose by increasing the supply of air and limiting that of water. In the laboratory it is possible by artificially reducing the supply of air to a soil plate to measure the resulting increase of the anaërobes present ; this may be done by enclosing the cultures in an airtight vessel from which the air or oxygen is then removed, or more simply by covering the surface of the medium with a glass plate. The results of many agricultural operations are modified by the intervention of anaerobes, especially in the case of the conservation of cattle manure, the ploughing in of green manures in wet soil, and wet rice cultivation, and laboratory investigations will, it is hoped, help to elucidate some of the problems connected with these operations in India.

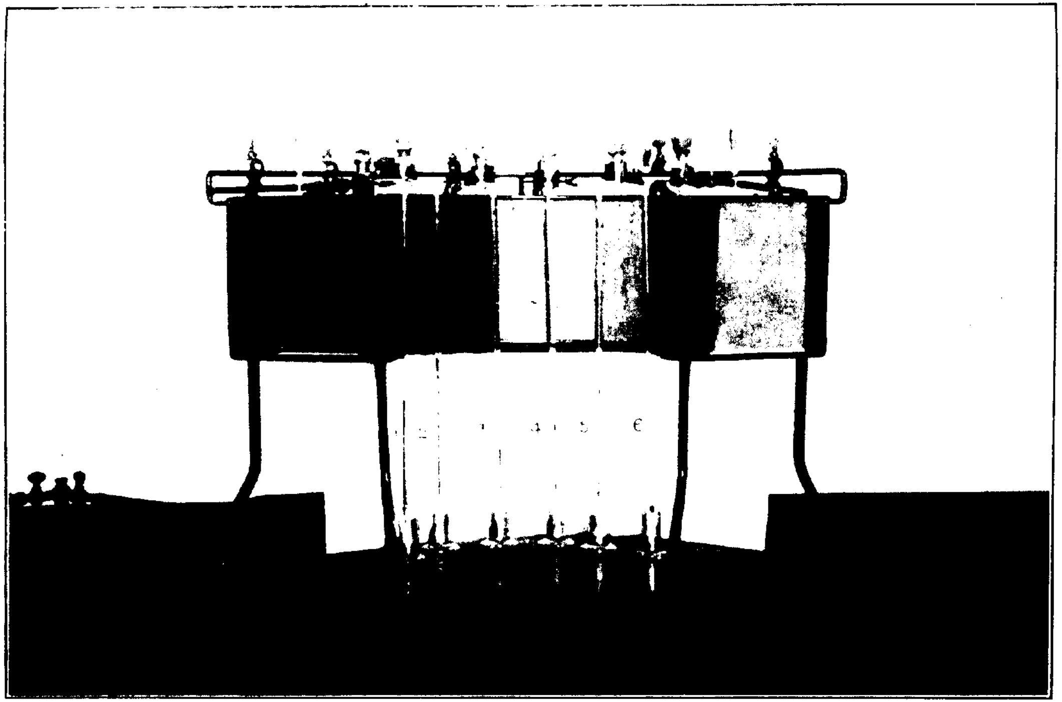
In addition to the loss of nitrogen produced by denitrification, further harmful effects are liable to follow from the prevalence of those conditions which give rise to it. A large number of soil bacteria are capable of acting upon organic matter in such a way as to produce organic acids, notably butyric acid, under such soil conditions as result from inefficient methods of cultivation with imperfect aeration and drainage. This is especially the case when large amounts of organic matter are introduced into the soil as green manures, without being followed by proper tillage and preceded by efficient drainage. Laboratory examination of soil in this condition reveals the cause by discovering the presence of an undue number of such bacteria as are associated with acid fermentation of organic matter. The acidity of the soil resulting from such conditions is most unfavourable for the proper operation of the beneficial micro-organisms described above, and in general terms may be said to reduce the biologic activity of the soil and therewith its fertility.

The life processes of bacteria result in the production of carbon dioxide gas, and in general terms it may be said that the amount of this gas formed in a sample of soil, containing no living higher plants, may be taken as a measure of the biologic activity of that sample. Dr. Russell of Rothamsted has devised a form of apparatus for estimating directly the amount of carbon dioxide formed in a measured quantity of soil, and this apparatus may usefully be employed for determining, not so much the relative biologic activities of various soils, as the effects upon the bacterial life contained in them, of such methods of treatment as we have been considering with reference to field practice. The photograph of this apparatus shows its general arrangement; the soil sample is introduced into a glass flask communicating with a side bulb containing caustic potash, and having a calibrated tube dipping into mercury, the whole being hermetically closed. In the photograph Plate XXII it will be seen that there are six of these flasks contained in a water bath to ensure even temperature, with calibrated tubes dipping vertically into mercury reservoirs. The carbon dioxide formed by the soil bacteria is absorbed by the caustic potash, thus lowering the gas pressure in the flask and causing a corresponding rise of mercury in the vertical tube; this rise is measured periodically and may be taken as indicating the relative amounts of bacterial action going on in the samples. Unfortunately, the results are liable to be interfered with by the evolution of other gases than carbon dioxide such as nitrogen and marsh gas, which may set up an increase of pressure and thus nullify the readings, and although this is not likely to happen in the majority of cases, the possibility of its occurrence limits the use of this apparatus in laboratory practice. Nevertheless it is of value in certain cases where it is desired to ascertain the effect of varying methods of treatment on the same soil, such as variation in percentage of water, or the addition of organic matter, or of artificial manures.

## Pot Cultures.

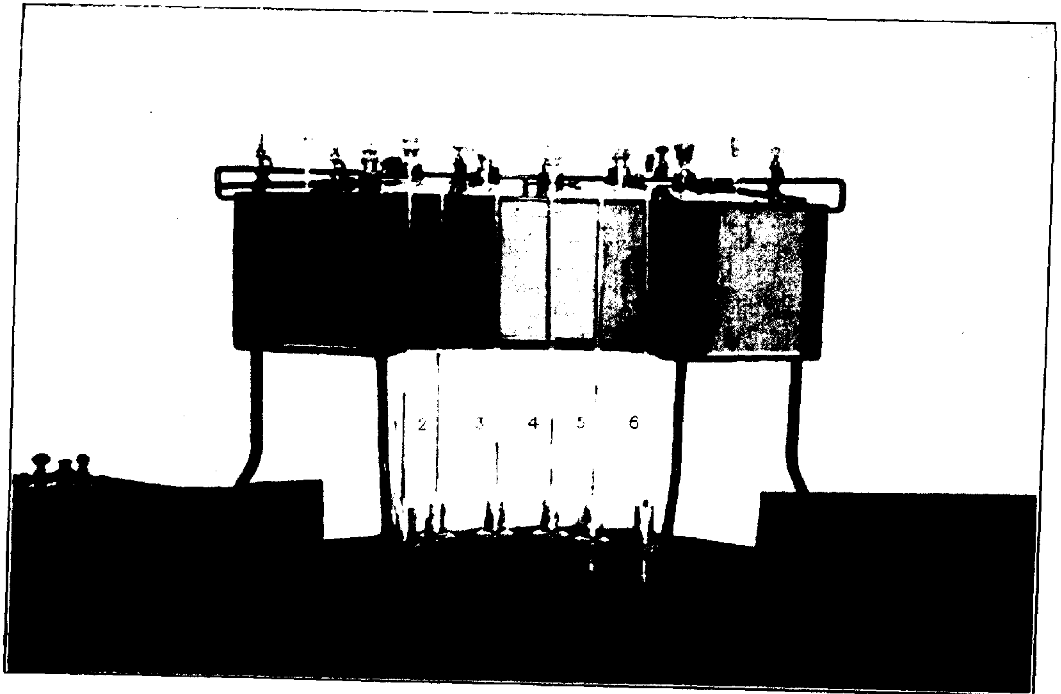
The general result of the individual activities of the bacteria which I have dealt with above, in modifying the fertility of the soil, can be only roughly estimated from theoretical consider-

PLATE XXII.



A. J. J. Dr. Russell's Apparatus

PLATE XXII.




A. J. I.

Dr. Russell's Apparatus.

ations; a nearer approximation can be arrived at by testing the fertilizing action of various bacteria by means of pot cultures. Owing to limitations of space I do not propose to describe this method, but will merely say that just as it is possible to make up artificial soils containing varying quantities of plant foods, so can various bacteria be added to a previously sterilized soil, and their action upon its fertility be noted. The principal difficulty lies in the initial stages of the work: to completely sterilize a soil without producing deleterious substances from the organic matter it contains is a matter of difficulty, and to avoid the accidental introduction of bacteria or fungal spores in the process of sowing seed in the pots requires very special precautions which may fail to ensure success, without affording any indication of their insufficiency at the time. I hope in a future issue of the Journal to give an account of the methods in use at Pusa to test the action of bacteria on soil fertility by pot cultures.

# RURAL ECONOMY IN THE BOMBAY-DECCAN.* II.

By G. F. KEATINGE, I.C.S.,

*Director of Agriculture, Bombay.*

*(Continued from page 318 of Part IV, Vol. V.)*

## IV.—Capital.

Before dealing with the many particular forms in which Capital is essential to the farmer, it will be as well to start with a few facts regarding the nature of capital in general.

Capital is wealth set aside to assist in future production. It can be employed in production not only by the owner, but by another who may borrow it for the advantages that he can obtain from it. The interest which he pays for it represents the price of the advantages which he hopes to obtain. This price, like the prices of other commodities, is mainly regulated by demand and supply, if we exclude the question of risk. Thus we find that in Europe the general tendency of the last thousand years has been for the rate of interest to fall, denoting a steadily increasing supply of capital. For loans on good security the rates of interest in Western countries have roughly fallen as follows :—

| | |
|---|---|
| 1400 A. D. ... ... ... ... ... | 10 |
| 1500 A. D. ... ... ... ... | 8 |
| 1600 A. D. ... ... ... ... ... | 6½% |
| 1700 A. D. ... ... ... ... ... | 5% |
| Present day ... ... ... ... ... | 4 |

In England at the present day a landowner can raise a mortgage on his land at about 4 per cent.

* For purposes of statistics the term Deccan has been taken to refer to the Central Division of the Bombay Presidency.

Space will not permit here to go into the history of loans to farmers in the Deccan and the interest paid by them in the past ; but it may be stated that at present a public body like the Bombay Municipality with first class security can borrow at 4 per cent. ; a holder of good land situated in a favourable part of the Deccan who has a reputation for honesty could raise a moderate mortgage on his land at about 9 per cent. ; while for a short accommodation on good security (*e.g.*, a standing sugar-cane crop), a man would have to pay about 15 per cent., a rate which has been fairly uniform during the past century. This high rate of interest in the case of good security is due to several causes. Capital is very scarce in the Deccan, and for want of organisation the cultivator cannot get in touch with the money market of the towns, and is often unable to realise what credit he has got. Further a creditor who finds it necessary to foreclose on a mortgage may discover that he has to face not only the worry of a civil suit but also a hostile combination of the cultivators in the village where the land is situated. In cases where the security is land but is less good than in the case mentioned above, a cultivator may pay anything up to 24 per cent. interest for a loan. Loans on personal security are made by particular classes of money-lenders and any rate of interest up to 100 per cent. may be charged. These rates of interest will appear to many to be very high ; but it is necessary to look at the facts from the point of view of the lender as well as that of the borrower ; and when consideration is paid to the risks of losing the capital, to the trouble involved in collecting the interest and to the personal enmity which the village money-lender often incurs, it may be doubted whether they are excessive. A century ago in parts of the Deccan, the village *bania* was afraid to stop in his own house, but would sleep in a different house every night, so as to elude anyone who might have designs to offer him violence. Even since the advent of more settled conditions the money-lenders of the Deccan have at various times been the object of open attack by the landholders whose lands they had acquired ; and in the present day cases are not uncommon where both the person and the property of the village money-lender are the subjects of violence on the part of the villagers.

Economists may truly point out that the man who provides capital is a public benefactor since, by the use of capital, production is cheapened and the community gains; but the prejudice against money-lending, which led to the strict rules against the taking of interest, framed by the early Christian and Mohamedan churches, is still shared by many. In the relations between money-lenders and cultivators there is much give and take; but in the long run the tendency is for the debtor to do most of the giving and the creditor the taking. Many instances can no doubt be cited against money-lenders of unfair bargains, harsh treatment and fraudulent accounts; but the fact remains that the small village money-lender does not usually acquire much wealth, though he often lives a more laborious and frugal life than many of his clients. If the risks, labour and, in many cases, the unpopularity of his calling be taken into consideration, it is doubtful whether the interest which he charges is higher than the conditions warrant.

To turn to the farmer's capital, its various uses may be tabulated as shown on page 117.

Many farmers would probably consider the above classification to be unnecessarily comprehensive, and to include forms of capital to which they pay little or no attention. If a man's business is to be put on a sound basis, however, and the maximum profit extracted from the land every form of capital enumerated above must be provided for in some way or other: and it is only by a proper understanding of each form of capital that correct accounts can be kept and the true source of profits and losses determined. With regard to the land and the labour supply, a farmer can often do little to alter the conditions in which he finds himself, and can only adapt himself to them as best he can. In the management of his capital, however, he has more scope for the exercise of discretion; and it is to a great extent on his business management that his financial success will depend.

- CAPITAL.
  - Fixed capital.
    - Land.
    - Permanent additions and improvements to the land, *e.g.*, buildings, wells and embankments.
  - Working capital.
    - Stock.
      - Live stock.
      - Dead stock.
    - Circulating capital, *e.g.*, manure, produce on hand, ready money for paying wages.
    - Reserve fund, *e.g.*, sinking fund, insurance, repairs.

To consider the various forms of capital in order—

*Land* has been already treated separately. When the farmer owns the land which he cultivates, it, of course, forms part of his capital. In the Deccan it unfortunately forms in many cases almost the whole of the cultivator's capital. Land should offer good security for borrowing at moderate interest the capital necessary to work it; and about half the land is mortgaged to a greater or less extent; but as has been already shown, the cultivator is often unable to realise his credit, and fails to obtain capital except at very high rates of interest. Even this would not matter so much if the money borrowed were all devoted to productive purposes, or if a reasonable sinking fund were established by the borrower to enable him to pay off the loan. But this is seldom the case; and the burden tends to become cumulative. It is unnecessary to say more about land as a form of capital except to observe that the more land a man has, the more of other forms of capital also he should possess, and that the farmer whose whole capital is sunk in land and permanent improvements is at a disadvantage as compared with a man owning less fixed and more working capital.

## V.—PERMANENT IMPROVEMENTS.

Few people probably, who are familiar with the landscape of rural England, realise what changes in the scene have been effected by the expenditure of labour and capital in the past. To note the difference it is not necessary to go back to remote ages when the valleys in many parts were covered with forest and swamp, and cultivation was confined to the higher ground. Progress has no doubt been continuous for centuries past; but it is the expenditure during the last two centuries on enclosures, field drainage, pastures, wind breaks and farm buildings, that has enabled the English farmer to survive the depression caused by the ruinous fall in the prices of agricultural produce, due to the foreign competition resulting from improved communications. The outcome has not been particularly profitable to the landlords who incurred the expenditure; since in many localities the value of land is now no greater than the cost of the buildings and other permanent improvements attached to it; and the owner has often been compelled to sell his land for anything that it would fetch to some one with an income derived from sources other than agricultural, who could afford to keep in repair the improvements that his predecessor had effected. But the matter is more than a question of money: and the landowners of England have this to their credit that they have borne the burden which every other country in Europe shifted on to the shoulders of the whole community by means of protective duties; and so have justified the policy of the 17th century which put so much of the common land in England into their hands.

To appreciate the significance of the improvements that have been effected the inquirer need not go further than the west of Ireland to see what unimproved land means; a desolate stretch of wind swept bog-land without a fence or a tree; with no signs of life but a few stray huts, each with its potato patch and guarded by a small boy to drive off stray animals. With capital laid out in reclamation this land might support the shiploads of emigrants who yearly make their way to America, and more besides. In default of such capital the tract becomes a "Congested District" by virtue of the scanty population which it retains. Conditions in India are very different to those in England, and there has not been much disposition on the part of the proprietors in the Deccan to improve and develop the resources of the land. In the western portion some careful and laborious terracing has been done on the hill sides by the smaller owners. Here and there a favoured tract will be well supplied with irrigation wells, and some farm buildings may be seen in the fields; but over the greater portion the landscape owes nothing to the hand of man, and the fields lie unwatered, unfenced and unembanked, without shelter for man or beast. In a dry country like the Deccan, the prime agricultural necessity is water, and in many localities where rainfall is scanty the annual produce of the land can be increased ten-fold by perennial irrigation. The larger irrigation works have been constructed by Government: and in the Central Division alone 110,000 acres are annually watered from Government canals. These irrigation works have in the past 40 years involved a capital expenditure of Rs. 260 lakhs. Work is in progress on additional irrigation schemes estimated to cost Rs. 211 lakhs; plans and estimates have been prepared for a large scheme costing over Rs. 300 lakhs and calculated to irrigate about 3 lakhs of acres in the driest part of the Deccan; while a preliminary survey has been made for irrigation works calculated to water $2\frac{1}{2}$ million acres in the Deccan and Southern Maratha country. Private enterprise is responsible for some 150,000 wells irrigating about 348,000 acres; for small tanks irrigating about 4,000 acres; and for the construction of dams and channels from streams which water 65,000 acres. These latter are led from a permanent or temporary dam, often with much ingenuity, along the contours of the bank till they can command a cultivated field.

From the above figures it will be seen that irrigation has not been entirely neglected. The fact remains, however, that out of 13,056,000 acres cultivated in the Central Division only 527,000 acres can at present be irrigated; that is to say, only 4 per cent. of the whole. The possibilities of large reservoirs are limited, and, such as they are, they are being realized by degrees. Few small streams which run for any length of time after the end of the rains are neglected by the cultivators; but there is a large field for profitable investment of capital in digging wells in localities where the subsoil water is reasonably near the surface. Another source of irrigation which is neglected consists in the perennial supply contained in many reaches of the larger rivers. The great difference in the water levels of the wet and dry seasons presents an obstacle to the convenient utilisation of such water, and conditions are seldom favourable for lifting it in the traditional way with the *mot*, or leather water-bag; but by the use of engines and pumps this difficulty can be overcome. Experiments are now being made with various kinds of engines and pumps to ascertain the cost of lifting water in this way; and there can be little doubt that under suitable conditions capital can be most profitably utilised in this way. A note of warning must however be sounded in connection with investments of this description. It is no use for a man to sink capital on such improvements unless he has sufficient working capital to run the plant. The same argument applies in a less degree to the construction of wells: for it is not an uncommon thing to find a cultivator who has exhausted his capital, and possibly his credit, in digging a well, and then finds that he has no means to work it properly or keep it in repair. A useful form of small investment consists in the construction of field embankments, known as *bils*, which prevent erosion and scour during heavy rain, and retain in the soil the rain water that falls. When combined with field levelling and tree planting, and skilfully executed, they are of much value. Such works may be large or small, and there is hardly a cultivator who could not make some small improvement of this nature every year at little or no cost beyond his own labour.

It has already been remarked that the cultivator very seldom lives in his holding. The farm buildings form part of the cultivator's house in the village and are for the most part of a very primitive kind. It is not to be expected that a man will lavish conveniences on his cattle which he does not obtain for himself; but it is certain that the absence of comfort and sanitation that characterises most cattle sheds must have a prejudicial effect on the stock. The surplus produce of the fields is seldom sufficient to demand elaborate store houses, but such as it is it often suffers considerably, the grain from weevils and other insects, the fodder from lack of protection against the rain; and for want of suitable buildings the cultivator often loses much of the profits of his labour.

In view of the high standard of cultivation in many parts the most remarkable feature is perhaps the complete absence of any permanent fences. A live fence cannot be produced at once, but in the course of a few years it can be produced at no cost beyond the labour of part of the cultivator's spare time.

The advantages to be derived from fences are not immediate or perhaps very obvious; which presumably accounts for the fact that none are made; but it cannot be doubted that very real and substantial advantages would be derived from their existence. Looking at the matter as it affects the crops, it is common to see growing crops seriously damaged by the inroads of stray animals; and in outlying fields the difficulty of guarding rabi or garden crops against such damage often deters the landholder from cultivating them at all. The cattle too, on their side, often suffer seriously from feeding on young crops; and roaming as they do over the unsheltered grazing grounds, the healthy with the diseased, live under circumstances which are anything but conducive to health and condition. Much of the labour now spent on herding cattle and guarding crops might be saved by the existence of well-kept fences, which would do the work far more effectively, and entail but little outlay either for construction or maintenance.

Writers are accustomed to contrast the output per acre of one country with that of another. Before such a comparison can be effective, consideration must be given to the capital which has been sunk in permanent improvements. In England such improvements have been roughly estimated as representing an average value of £12 (Rs. 180) per acre. Allowing 8 per cent for interest, depreciation, repairs and insurance, it will be seen that the net annual charge against each acre of land on account of permanent improvements will be about £1 (Rs. 15). As regards the Deccan if we take Rs. 400 as representing the average cost of a well (taking masonry and non-masonry wells together), the

| | |
|---|---|
| capital sunk on wells amounts to ... | Rs. 60,000,000 |
| Add capital cost of Government irrigation works ... ... ... | ,, 26,000,000 |
| Add capital cost of private irrigation channels from streams and small dams (rough estimate) ... ... | ,, 4,000,000 |
| Total ... | ,, 90,000,000 |

The capital cost of irrigation works thus comes to about Rs. 900 lakhs. Dividing this by 5 lakhs of acres irrigated we find that for irrigated land the capital sunk in permanent improvements works out to about Rs. 180 (£12) per acre, or the same sum per acre as is estimated to be sunk in permanent improvements in England. The above calculation is of necessity a very rough one, and takes no consideration of outlay in levelling land, which is frequently necessary where irrigation facilities exist. It will suffice however to show that in comparing English with Deccan outturns per acre, it is the irrigated land which, from the financial point of view, offers the best basis for comparison ; while as regards the unirrigated land which forms 96 per cent. of the whole cultivated area, it must be remembered that in the matter of permanent improvements there is little for which the present has to thank the past : for the amount of capital per acre sunk on permanent improvements is almost negligible. If the gross outturn per acre obtained on the dry lands of the Deccan compares badly with that obtained in England, this fact must not be overlooked.

# THE PROGRESS OF AGRICULTURE IN JAPAN.*

REVIEWED BY A. McKERRAL, M.A., B.SC.,

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In a preface to this little book of 130 pages by the Director of the Agricultural Bureau, the object of the book is stated as being "for the purpose of acquainting foreigners with the general outlines of agriculture in Japan," and as the book has been written by a Japanese, an apology is offered for the English in which it is couched. There are certain passages which, as the preface says, "lack intelligibility" more or less, and it certainly is regrettable that the book was not placed for revision in the hands of a competent English scholar, but on the whole the expression is probably clearer than one might have expected under the circumstances.

Most readers of the Journal will doubtless have derived their ideas of modern Japanese Agriculture from the note by Sir F. A. Nicholson, reviewed in this Journal (Vol. III, part I) by Mr. E. Shearer. The note above mentioned, however, dealt more or less with the existing conditions of to-day: the present volume is retrospective as well. It is divided into 3 parts, which deal respectively with the conditions, past and present, of Agriculture in Japan, Agricultural Products, and Agricultural Administration, and in an extremely concise manner (so concise as to be occasionally rather bald) it presents us with both the results and the methods of twenty years evolution of Japanese Agriculture.

The progress of agriculture in any country may fairly be estimated by the extent to which improvements in tillage, seed

* "Outlines of Agriculture in Japan," [illegible] By the Agricultural Bureau, Department of Agriculture and Commerce, Tokyo, 1910.

selection, manures, implements, and live stock have taken place, resulting in an increase of the total acreage under cultivation, an enhancement of the total produce and of the yield per acre, an improved quality of the produce, and a rise in the prosperity of the agricultural population. Judged by these standards the agriculture of Japan, as described in part I of the book, has made striking progress during the last 20 years.

According to the table on p. 37 the areas of the principal crops cultivated have increased during the period 1887-1907 as follows :—Rice 10%, barley 5%, naked barley or rye 21%, wheat 12%, soy-bean 1%, buckwheat 5%, sweet potatoes 30%, and potatoes 28%. In addition to these purely agricultural crops mulberries have shown the striking increase of 69%, millets, cotton, and indigo have declined, owing to foreign imports and artificial production, but to take their place fruit, vegetables, pea-nuts, peppermint, and other minor crops have increased in area.

These striking increases have been brought about by active governmental measures fostering reclamation of land, irrigation, drainage, and what is called adjustment of farm lands. The latter work is, perhaps, the boldest of all the schemes which have been tackled by the Government in Japan, and it speaks much for the perspicuity of those at the head of affairs that they realized that it lay at the foundation of agricultural progress. The arable land of the country is parcelled up among holders whose average holdings are not more than 2.45 acres in extent, the holdings themselves being often subdivided, with the sub-divisions not contiguous to each other, and forming, as in many parts of India, a network of minute, irregularly shaped fields. Under such conditions improvements in the direction of improved implements, irrigation, drainage, etc., are difficult and often impossible ; and accordingly, in 1899, laws were made in Japan encouraging owners of land to consolidate their holdings, straighten the boundaries of their fields, and provide roads and other conveniences. In taking these measures "the Government expected to lay a perfect foundation for agricultural undertakings both at present and in the future. . . . the investigation made at the end of the year 1909 shows that the area of the land thus adjusted throughout the country has reached 178,000 *cho* (about 490,000 acres). The work, however, is naturally very slow, and as yet about $\frac{1}{10}$ only of the paddy fields have been so adjusted. These measures, however, mark more than anything else, the *thoroughness* with which the improvement of agriculture has been tackled, and should furnish a useful object lesson to all who have realized that the scattered, irregular, and minute fields of the Indian cultivator form a very real bar to progress. In his note Sir F. A. Nicholson, speaking with special reference to Madras, has the remark that possibly as "Settlement and Survey work proper declines, the 'Verkoppelung' of scattered plots will employ the parties," but he suggests that it would be far better for the village associations to carry out the work themselves. In whatever way the desired result may be brought to pass, it must come before *real* progress can be made. No less than the consolidation of holdings the construction of regularly shaped fields, with roads at proper intervals and affording facilities for irrigation, drainage, and the use of improved implements, is just as crying a necessity in many parts of India as it is in Japan.

The work of irrigation and drainage has also shown remarkable progress. Historical records show that irrigation was a subject that received much attention from the rulers of Japan, even at remote periods in its history. This policy has been continued, and in recent years steam and electricity have been adopted "by the united efforts of farming communities" to pump water into the paddy fields. In March 1909, there were 7[illegible] places where mechanical irrigation devices on a large scale were employed. In addition to irrigation, the drainage of paddy fields has received much attention during recent years. It is common to raise winter crops after the harvesting of the paddy, but in many places it was found impossible to do so, owing to the high level of the underground water. Accordingly, recourse has been made to drainage, either the open or underground system being employed, and where natural drainage has been found impossible, mechanical devices have been brought into use . . . .

"According to investigations made in March 1909 there are 47 places where provisions for mechanical drainage are adopted, and the area of the land drained off reaches 7,500 *cho*" (1 *cho* = 2·45 acres). The book does not give details as to the pumping apparatus used for the purpose, but a photograph illustrative of it is shown at page 20. These extensions of drainage and irrigation have, needless to say, been much facilitated by the adjustment of lands above described.

In the introduction and use of artificial manures great progress has been made in quite recent years. The Japanese cultivator is naturally a careful economist, and from time immemorial has husbanded with scrupulous care such fertilizers as he found ready to hand. Twenty years ago, we are told, human excreta was, as it still is, the great natural manure. Weeds, farm manure, and ashes of plants were regarded as manures of comparatively inferior quality, and among manures purchased were oil cakes, fish guanoes, and rice bran, but the three latter, we are told, were little used then. At the present day the principal artificials are, in order of value consumed, soy bean cakes, superphosphate of lime, mixed artificials, rape seed cake, herring cakes, bone dust, cotton seed cake, and the total average consumption per annum for the three years 1905—07 amounted, for the whole country, to about 38,000,000 *yen* or nearly 570 lakhs of rupees. Superphosphate has attained to remarkable importance as a manure, the phosphate rock being apparently imported and the manufacture of the manure done in the country.

One turns with considerable interest to what is said on the subject of agricultural implements, expecting to find commensurate progress with that effected in manures. It is rather disappointing to find no details given, but such, however, would probably be without the scope of the book, which is meant to give a general outline only. The intensive nature of Japanese agriculture seems to have made the introduction of large and modern European or American implements impracticable, and the implements used at the present day are still mostly of wood. Within recent years, however, it seems that inventors of new agricultural implements have not been wanting and that over 400 patents have been granted for models which are "quite adapted to practical purposes." From the Indian point of view it would have added considerably to the interest of the book if photographs of indigenous or improved Japanese implements had been supplied.

A table on page 39 gives the outturns of the principal crops per "tan" for the years 1887, 1892, 1897, 1902, 1907, the figures given for each of the above dates representing the average outputs of the five preceding years. With the single exception of cotton, all the crops showed a marked increase in output and in the case of the principal crops this is strikingly exhibited. Thus rice has increased by about 23%, barley by 36%, "naked barley" or rye by about 10%, and wheat by about 28%. If these figures are reliable, they offer a convincing proof of the success which has attended the introduction of improved agricultural methods during the last two decades.

The second part of the book deals with agricultural products. The description of the cultivation of the principal crops is too short, and might with advantage be expanded if further editions of the book are contemplated. The accounts given of the silk and tea industries are somewhat fuller and are accompanied by excellent photographs. In the same part the animal industry and several small subsidiary industries engaged in by the agricultural population are dealt with.

In connection with the animal industries a determined effort is being made to improve the breeds of cattle both for beef and milk purposes, and foreign bulls have recently been largely imported. No account is given in the book of the indigenous cattle of the country. In the case of horses we are told that "various lords in the Feudal times issued regulations regarding horse affairs with a view to the improvement of breeding. The result has proved to be perceptible . . . . . . in the case of the Nambu-horse." A committee for the investigation of horse-breeding was formed in 1896 as a result of the war with China and worked under the control of the Department of Agriculture.

It established horse breeding depôts and imported stallions. After the war with Russia in 1904-05 the subject of the supply of military horses was realized to be so important that a special Horse Administration Bureau was formed which is under the direct control of the Cabinet.

In Japan there is no native breed of sheep, but apparently they were imported (we are not told from where) some forty years ago, and an American expert brought over to instruct on sheep farming. This attempt was unsuccessful, but in recent years they have been acclimatized. Several breeds of goats exist in Kyushu, and apparently other breeds have been recently introduced. Swine and poultry receive attention at the Imperial Stock Breeding Farm at Tokyo, and poultry farming as a subsidiary industry to agriculture has shown an encouraging development of late years.

The subsidiary occupations are a great help to a community of small holders such as the Japanese are, and are undertaken by such members of the household as can be spared from the ordinary labours of the farm, or they occupy the time of the farmer during slack seasons. The principal are straw and chip braid-making, straw matting, ropes, bags and sandals, fancy mat-making, weaving, the manufacture of paper and of various articles from bamboos and osiers, bee culture which has been in existence from very ancient times, and the culture of carp in specially constructed ponds or in the paddy-fields as an adjunct to the cultivation of the latter crop.

The third part of the book deals with agricultural administration, and describes concisely the administrative and executive machinery which have effected the progress sketched in Parts I & II. It has a chapter on the history of agricultural development and the bureau of agriculture, another on the organs of agricultural investigation, which describes the Imperial Agricultural Experiment Station, Local Agricultural Experiment Stations, the Sericultural Institute, the Conditioning House, Stock-breeding Farms, etc. Another chapter deals with agricultural education and gives a succinct account of the agricultural college of the Imperial University, higher agricultural schools, ordinary agricultural schools, agricultural institutes and supplementary schools, lectures and peripatetic instruction. A further chapter describes what has been done in the way of formation of agricultural societies, co-operative societies, staple product guilds, rice inspection systems, rice depôts, the sugar improvement office, shows and exhibitions, and agricultural banks.

Most of the details connected with administration, education, co-operation and credit, and other aspects of agricultural development, have already been presented to Anglo-Indian readers in Sir F. A. Nicholson's note. The present volume posses ses some extra interest in that it gives a short historical account of that development an aspect of the matter of supreme interest to us in India, where systematic agricultural work may be said to have only just begun. The author of the book divides Japan's agricultural development up to date into four distinct periods :—

1. The thirteen years from 1868 to 1880.
2. The ten years from 1881 to 1890.
3. The fifteen years from 1891 to 1905.
4. From the year 1905 to the present.

The first period was that of Japan's awakening, when Western ideas in all departments of life were being feverishly copied. Agricultural experts were invited from abroad, and new and improved varieties of crops were introduced and distributed. The result of this period, which has a parallel in the agricultural development of practically all countries, and which might be designated the period of the enthusiastic amateur, ended in failure. Government interference in these matters was deprecated by the people themselves, and among even the more intelligent class the policy of *laissez faire* in agricultural matters was advocated. Failure resulted, as it was bound to result, because in the first place no definite branch of the administration was specialized to deal with agricultural matters; and secondly, because the people themselves were poor, ignorant, and lacking in enthusiasm.

The second period, 1881-1890, was marked by the creation in 1881 of a Department of Agriculture and Commerce, with a special Bureau of Agriculture. Successful development dates from that year. The new department fostered shows, conducted agricultural experiments, appointed circuit instructors to influence the masses, and in stock-rearing, sericulture, and other matters, made a good beginning. As yet, however, it had not, to use a phrase much employed in India, "got at" the people.

It was in the third period that the important problem of getting at the people, of bringing a nation of poor small holders into organic connection with the government, was successfully tackled and solved. The beginning of the period was marked by the opening of the Imperial Parliament, which at once instituted a bold and progressive policy in agricultural matters. In 1893 the Imperial Experiment Station at Tokyo was founded, followed by the Sericultural Institute. The war with China gave an added impetus to the work, demonstrating as it did the necessity for husbanding and utilizing in the most economical manner the national resources. Agricultural banks were founded, experiment stations were more highly subsidized, and laws for the adjustment of lands and for the formation of agricultural societies, and of co-operative credit societies, were passed in rapid succession. The period ended with the Russian war in 1904. Its outstanding features were undoubtedly the introduction into agricultural policy of the two features of co-operation and credit. In 1900 Government issued the rules for the regulation of agricultural societies, realizing, apparently, that any attempt to get at individual cultivators was not likely to prove successful. These societies are of three kinds—prefectoral societies, county and city agricultural societies, and town and village societies. County societies consist of the town and village societies of the county, and prefectoral societies consist of the county and city societies in these districts. When two-thirds or more of a community voluntarily form a society the remainder are regarded by the law as joining the association.

The societies pay their own expenses, but subsidies are received from the exchequer and from local and county funds in order that they may carry on extra works. Their objects are :—To establish farms or nurseries for seeds and seedlings, especially of rice and mulberries : to conduct lectures and demonstration : the introduction of new varieties and new methods of cultivation : the creation of co-operative credit societies to act as mediators for joint purchase and sale : to collect statistics, to encourage subsidiary industries, exhibitions, sericulture and stock-farming, and to publish society reports. Their functions in short somewhat correspond to those of the various agricultural societies which are a common feature of European agriculture. The success of this movement may be gauged from the fact that the number of village societies now totals up to nearly twelve thousand.

In a nation of small holders with small individual capital, more, however, was required. Accordingly the Co-operative Credit movement was started in 1900. It also has met with an equal measure of success. Credit societies have as their aim "to supply capital at a low rate of interest to persons under the middle class, to accelerate mutual profits, and to make economic and productive developments." They are of four kinds :—

(*a*) Credit societies for the advancement of capital and to facilitate savings.

(*b*) Sale societies—to effect sales of articles which may or may not be finished.

(*c*) Purchase societies—to purchase articles necessary for productive industry for the members of the society.

(*d*) Productive societies—to finish articles which have been partially produced by members, or to furnish members with articles necessary to their industry. Members of these societies are exempt from income-tax and can have funds from local hypothec banks without the deposit of securities. The societies have now reached the total of 5,500, and have at their command a capital of 40,000,000 yen or 600 lakhs of rupees. The societies have further confederated themselves : thus there exists a confederate association of credit societies, and one each of sale, of purchase, and of productive societies.

It is impossible within the scope of this article to enlarge further on the work done by the Japanese government. The success achieved undoubtedly rests on the application of the two great principles of co-operation and credit. The experience of Japan proves clearly that scientific research and education, all important as they are as factors in agricultural improvement, must go hand-in-hand with co-operation and credit. The great problem in India, as it is in Japan, is to "get at the cultivator." The account given in the book under review has proved decidedly that co-operation plus credit is *the* method of doing so. Research and agricultural education accompany as powerful auxiliaries. It augurs well for success in India that the policy being adopted here is substantially that adopted with so much success by Japan. Whether an equal measure of success will be achieved remains to be seen. Behind all governmental measures and policies there must exist the greatest factor of all—national character—and the progress depicted in the pages of this little book, achieved concurrently with victory in two great wars—speaks wonders for the courage, determination, and patriotism of the Japanese people. We would gladly welcome a second and enlarged edition of the book. Despite its literary defects, which are quite excusable and easily remediable, it has fulfilled its object of "acquainting the foreigner" with what Japan has done. The statement of success which it records must have caused the department which has issued it a good deal of quite pardonable pride.

# EXOTIC COTTONS IN SIND.

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## I.—Egyptian Cotton.

As it will in all probability be possible to sow Egyptian cotton in 1912 on the Jamrao Canal, attention is invited to the following precautions which, in the opinion of the writer, it is necessary to secure:—

(a) Proper cultivation including sowing before 1st week in April, avoiding "*kalar*" ground, and if possible growing in rotation with *berseem*.

(b) The provision of a system for disposal, ensuring proper treatment after marketing seed cotton and for ginning, grading and selling at current market prices.

In order that the cultivation shall be properly supervised, it would be advisable to appoint two *mukhtyarkars* on special duty one for the north of the Jamrao and one for the south, to be under the immediate orders of the Agricultural Department. They would begin work at the beginning of 1912. Their duties would consist in seeing that the cotton seed was properly distributed and that suitable land was cultivated. They would continue on duty till picking time when they would take charge of one sub-station each for the collection of the cotton.

The cultivation of the plant is by far the simpler part of the problem. It was not long since an area of 6,000 acres was obtained mainly by the influence of the Colonisation Officer, Mr. Chatfield. The disposal of the produce, however, is a more difficult matter. Formerly two varieties of cotton were grown

*Abassi* and *Mitafifi*. These were collected from the cultivators in sub-depôts and sent to Mirpurkhas in different lots and sold by auction. There were always considerable variations in the quality, cleanness and value of the different lots, but for the first few years very fair prices were obtained. The buyers were of two classes:

(*a*) Mill-owners from Ahmedabad and Bombay.

(*b*) Exporters from Karachi and Bombay.

The mill owners, several of whom use imported Egyptian cotton, soon stopped coming. They complained that when they bought Egyptian cotton in Alexandria or Liverpool they got a certain grade, *e.g.*, "Fully Good Fair," which was uniform and could be depended on to produce certain "counts." Whereas for Sind Egyptian, they had to send their agents to Mirpurkhas at an unhealthy time of the year and not knowing Sindhi language were at a great disadvantage. To buy any quantity, they had to bid for a number of small lots, some dirty, some stained and some good. These they had much difficulty in getting ginned as the local gins which are only suited for short staple cotton had plenty of work of their own. There does not, therefore, seem to be the least chance of mill owners taking the cotton direct from the cultivators; on the other hand, they would probably use a considerable quantity if an assured supply of baled and graded cotton was available. A mill-owner is not a cotton broker and the cotton broker is an essential link between the cultivator and the user of the cotton. An Indian cotton broker has no knowledge of Egyptian cotton as a commercial knowledge of one kind of cotton takes a life time to acquire. A sample of "Fully Good Fair" *Mitafifi* submitted to a leading Bombay exporter was stated to be a "foreign variety of a bad colour!"

As regards the exporting firms, they always fought shy of *Mitafifi*; and one firm got "its fingers burnt" by sending a consignment of so called *Abassi* to Liverpool. It had never been properly cleaned and was full of dirt and pieces of leaves. Naturally it was unsaleable. It does not seem probable that Indian export firms will take up an entirely new and unproved branch while they have as much work as they can possibly do with existing cottons.

Carefully taken average samples of *Abassi* and *Mitafifi* have been forwarded to three leading Alexandria brokers during the last few years. Their verdicts are very important and are all unanimous to the effect that the *Mitafifi* is of a good strong and useful quality, but that the *Abassi* would never grade as such in any market. The *Mitafifi* has been up to the standard of "Fully Good Fair," which is to say, if properly cleaned, properly ginned and baled and sent to Liverpool, it would fetch the current price for "Fully Good Fair" Egyptian brown. It is not to say, however, that if passed through an "opener" badly cleaned or crushed while ginning in a gin meant for Indian cottons, it will reach this grade. There is no sale for *Mitafifi* in India; it is not used and its colour is against it. It will, therefore, be necessary to export it. As for *Abassi* it is quite useless to continue it, as it is not up to export quality; and though it might be sold in India as a miscellaneous cotton, it would probably not yield as well as ordinary Upland American in price and produce. The cultivators on the Jamrao generally hold what experience has already taught in Egypt, *viz.*, that *Mitafifi* is hardier all round than *Abassi*. However, as *Abassi* has always brought a high price at the auctions, the cultivators have generally elected to grow it.

Briefly then if the above proposed scheme for superintending the cultivation were adopted, after harvest the cotton would be gathered in a few conveniently selected sub-depôts. Only clean cotton would be accepted and one uniform grade of *Mitafifi* would be produced. Two alternatives are then possible: (a) that the British Cotton Growing Association be asked to step in at this stage and clean, gin, export and sell the cotton, or (b) that Government, by means of the existing Agricultural Department, should buy the crop outright, export and sell it for a few years to see if local firms will then take it up. The first is by far the simpler method and if a good area of, say 10,000 acres *Afifi* could be guaranteed, it would be worth the trouble of the British Cotton Growing

Association to send an experienced agent to take over the cotton at Mirpurkhas and to clean, gin, bale and export it. Arrangements could be made to get half the value paid to the cultivators on delivery at the sub-depôts, and the remainder after selling at Liverpool.

The writer is very strongly of opinion that it would be much better to stop the cultivation of Egyptian cotton altogether, if it is not proposed to provide means for the disposal of the produce. Provided the cultivator gets Rs. 12, or over per maund of 81 lbs. for seed *Afifi*, it will be more profitable in average years than cultivating Sindhi cotton. The average yield under fairish cultivation may be put down at 5 maunds per acre : under similar conditions the yield of Sindhi cotton might average 7 maunds at Rs. 6 per maund.

## II American Upland Cotton.

From fairly extensive trials it is now certain that a good class of American cotton can be produced under average circumstances in Sind. It has the following advantages for general cultivation :

(*a*) Short growing period, shorter than Sindhi, and thus it can be sown on inundation canals. There is consequently a very large area on which it can be grown.

(*b*) It is hardy, but is easily affected by "*kalar*" and on lightish land it suffers severely from white ants.

During the past year, some good yields were obtained, and in many cases it produced as much seed cotton as neighbouring plots of Sindhi. In other places, however, it suffered from white ants or "*kalar*." The reports from Liverpool brokers were good both as to quality and ginning percentage. They stated that it was exactly the stuff required by Manchester and that they could take it in any quantity.

The disposal is the difficult point. Local buyers do not seem to care about dealing in it, and in some cases growers last season mixed it up and sold it as Sindhi. Very little seed was distributed to zemindars this season, though many applications were received for the above reason. During the present season, American cotton is growing at the following places :

| | |
|---|---|
| In Upper Sind where practically no cotton is at present grown | Jacobabad.<br>Shikarpur.<br>Sukkur.<br>Ubauro. |
| In Lower Sind ... ... | Noushahro Feroz.<br>Nawabshah.<br>Halla.<br>Nara Valley.<br>Mirpurkhas.<br>Hyderabad.<br>Tando Mahomed Khan.<br>Talhar.<br>Phuleli Escape. |

This only leaves out Larkana and Karachi districts where for want of necessary staff it is not under trial. Provided that results from the above centres are successful, it will be necessary to arrange some means of disposal before any extension of the cultivation in the districts can be contemplated.

The difficulties pointed out with regard to Egyptian cotton apply also, though in a somewhat less degree, to American cotton. If the British Cotton Growing Association can be persuaded to take up the disposal of Egyptian, they could at the same time deal with the American cotton crop. For season 1912 a considerable area of cotton could be guaranteed, as there is a large area to take in Upper and extreme Lower Sind which, at present, grows practically no cotton at all.

If it is not possible to arrange in the way as suggested above by the writer, the only alternative will be to sell it departmentally. It is very necessary to fix some scheme for disposal, otherwise it would be much better for the agricultural staff in Sind to devote its attention to the subject of the local Sindhi cotton and to leave the exotic cottons alone.

# SOFT ROT OF GINGER IN THE RANGPUR DISTRICT, EASTERN BENGAL.

BY WILLIAM McRAE, M.A., B.Sc.,

*Supernumerary Mycologist.*

*Soil.*—For the successful cultivation of ginger, light, sandy loam or loam that is well drained is necessary. On clay the crop does not thrive because of the greater amount of water retained in and on the soil. The rhizome does not form well, and the chances of its becoming diseased are greater in places that suffer from damp or where water is stagnant. Ground that has remained fallow for three or more years, having usually become over-run by thatching grass is in this district generally chosen as the site for a ginger crop; and the field, after bearing a single crop, is not again planted with ginger for a period ranging from three to ten years, though five years is a common time. This long interval is said to be necessary partly because the crop is an exhausting one on the food-content of the soil and partly because it is so liable to disease when planted more often.

2. *Cultivation.*—As good drainage is one of the most important considerations for the successful cultivation of a ginger crop, great care is taken to prepare the soil and ensure that water does not stagnate. The land is spaded, ploughed, cross-ploughed and laddered till it is brought to a fine tilth, so that the roots may easily ramify in the soil and so better procure the plant food available. Then the field is divided into parallel beds seven feet wide, separated by channels one and a half or two feet wide and eighteen inches deep. Besides these, in well cultivated fields there is a drain about two feet deep all round the field, for the purpose of carrying off the water from the parallel drains, which communicate with it. The ginger "seed"

is planted across these parallel beds in rows about one and a half feet apart. A light plough is drawn by hand to make a shallow furrow two or three inches deep and in it the seed is planted, each piece about four to eight inches apart. The earth is then closed evenly over the furrow. In a month or six weeks the plants have sprouted and, when they have grown about six inches high, one earthing is made. The field is kept thoroughly clean of weeds and one, or at most two more earthings may be required, so that finally the ginger lines are converted into ridges and the places between the rows of plants become furrows, which lead drainage water into the parallel drains. In this way a perfect drainage is assured in the field. Nothing more is required till the time of harvest except to keep the field clear of weeds.

3. *Curing.*—The crop is generally harvested from January to the end of February. If, however, the price of ginger is high, the cultivator will take up his crop any time after October. When dug up the mature rhizomes are cured. After being washed and having the small roots picked off they have the outer corky rind scraped or removed and are laid out on mats in the sun to dry. They are turned once or twice each day for about a week, when the ginger is quite dry.

4. *Area under ginger in Rangpur.*—The area under ginger in Rangpur district is not definitely known. In the forecast for *rabi* crops from Nelphamari, the largest ginger-growing sub-division in the district, 1,000 acres are put down under *rabi* non-food crops, the area of individual crops not being specified. Fully two-thirds of this area may be taken as under ginger, so the area in Nelphamari is about 700 acres. For the other three sub-divisions 800 acres is a fair estimate. Thus the area under ginger in Rangpur district is about 1,500 acres.

5. *Jaindhara disease.*—The ginger seed is planted out in March and by the middle of August or September, the plants are about $1\frac{1}{2}$ feet high. Then a disease, locally known as Jaindhara, begins to manifest signs of its having attacked the plants. (Vide *frontispiece.*) Year by year this disease attacks the crop and

has done so for several years. A few of the young leaves become yellow and begin to die in the month of July, and by the middle of August the disease is spreading rapidly. The expert cultivator easily recognises the disease and knowing by experience that it is infectious removes from the fields as soon as possible the yellow leaved plants which have become rotten. The removed plants are thrown into an out-of-the-way corner and left to decay. This process of removal goes on till the end of September, when it is discontinued, and the diseased are allowed to grow with the healthy plants till well on in November, when they are partially mature. They are then dug up and sold off in the market at whatever price they will fetch. The healthy plants remain in the field and are harvested later, up to January, or February. Partially diseased rhizomes being discoloured, soft and watery, do not cure well and the outturn when cured is small, while badly diseased ones are useless.

6. *Active period.*—It may be noted that the disease appears with the advent of the rains and becomes epidemic only when the rains have fairly well set in and the ground is wet. In damp fields where the soil is stiff and retains water the attack is always more severe, while on sandy loam the disease does not usually reach an epidemic stage. When the rainy season is about at a close, the removal of diseased plants ceases and any later attacked plants are allowed to remain in the ground to do what they can before being finally taken up and sold as inferior quality ginger. The cultivator has learned by experience that, after the rainy season is over, there is little fear of the disease spreading much.

7. *Damage.*—The disease is widespread throughout the district, and it would be difficult to find any considerable acreage where it is not present. Even taking a low estimate the loss runs into a good many thousand rupees. Near Surat in 1904 in one village alone, visited by Dr. Butler, the loss was estimated at 10,000 rupees. The damage is always more marked in damp soil where there may be a yearly loss of 10 to 15 per cent. of the crop, while in dry soil the disease appears only in patches and the loss may be 5 or 6 per cent. If, however, in a wet year the

diseased plants are not removed as soon as observed and the crop is allowed to grow with little care, the whole crop in a damp field may be all but lost. In a three-acre field near Kanail Khata, in the Nelphamari subdivision, the ginger grew on a site that had not borne ginger for many years. The soil was a sandy loam and the plants had been kept free of weeds. About twenty per cent. of the plants showed signs of disease. Here the dying plants had been pulled up by the collar and thrown down in the furrows but no attempt had been made to remove infected rhizomes. The cultivator was trying to check the disease but had not gone far enough. About a mile away another field which had been uncultivated for, it was said, fifteen years had about 80 per cent. of the plants diseased at the end of September. The soil was not well cultivated and was badly drained, and the cultivator had done nothing to try to stop the disease. Healthy and diseased plants were growing side by side, the latter gradually infecting their neighbours. This apathetic attitude with regard to the disease is not, however, general. Cultivators know the disease quite well and try to overcome it by planting good seed only and by removing the visible parts of the decayed plants, but not knowing the cause of the disease nor its method of spreading, their precautions are not thorough enough. They do not dig up and remove the diseased rhizomes as soon as they are affected nor do they realise the necessity of destroying the affected parts. It is a too common practice, when harvesting the crop, to leave diseased rhizomes in the ground as not being worth lifting. Single plants or whole patches are often left. They slowly decay and keep the fungus causing the disease alive for a long time. Thus it has come to be the usual and necessary course not to grow a ginger crop in the same field till after the lapse of several years.

8. *Rangpur Experiments.* —No ginger crop is grown in the immediate neighbourhood of the town of Rangpur, but on the Experimental Farm under the management first of the Agricultural Department and then of the Agricultural Association of Rangpur, experiments in ginger have been made annually since 1905-06.

Small plots of ginger from the four localities. Jamaica, Cochin, Calicut, and Bengal, have been grown. All the plots were attacked by disease and rather severely in 1907. "As a preventive against the disease precautions were taken when harvesting the crop to remove all the rhizomes from the soil and those which showed any signs of disease were destroyed. The new crop was planted as far away from the site of the old crop as possible, and as far as could be ascertained by the eye, only healthy seed was used for planting."* In August 1908 only a few of the plants manifested signs of disease. All the four varieties had the disease and it increased slightly as the season advanced. The weather had been rather unfavourable to the development of the disease, as it remained dry up to the beginning of this month. The plants were slightly below the normal height of an ordinary season. In the previous year at this time the disease had attacked a large proportion of plants. Jamaica ginger imported and grown in the previous year almost succumbed, scarcely yielding more than enough for seed for this year. When planting for the 1909 crop similar precautions were taken and the seed was chosen most carefully. In October towards the end of the rains not a single diseased plant was found, though a sufficiently large number of plants were dug up and dissected to make sure. An insect pest, however, was doing a good deal of damage to the shoots. It was the larva of a Drosophelid fly which lives on coarse grasses. It probably came from a piece of jungle close by, where part of the refuse of the town was being conserved.

9. *Symptoms of disease.*—The first outward indication of the disease in the growing crop is a general but slight paleness of the leaves of a shoot, then the tips of the leaves turn yellow, and this yellowing gradually spreads along the leaf towards the leaf sheath, often more rapidly along the margins. Then the leaf-tissue dies and becomes scarious from the tip, the dead area gradually extending towards the leaf-sheath following in the wake of the yellow discolouration. The leaves droop and hang down

* Annual Report of the Agricultural Stations in Eastern Bengal and Assam for the year ending 30th June 1908, page 30.

along the stem, till finally the whole shoot becomes dry and withered. Meantime the collar, that part of the aërial stem between the place where it arises from the rhizome and where it emerges from the ground, becomes of a pale, translucent brown colour and, by the time the leaves are well yellowed, it is very watery and soft so that the whole shoot can easily be lifted off, breaking away at this point, though not falling over spontaneously. This soft rot also extends beyond the collar into the rhizome. The rotting is accelerated by the combined action of other fungi and of small eelworms and the larvæ of flies which act as secondary agents. Both the discolouration and softening extend to the whole rhizome which gradually rots and disintegrates forming a loose watery mass of putrifying tissue enclosed by the tough rind. The vascular strands lie isolated inside. The roots attached to the affected parts also present the same symptoms. (Plate XXIII.)

10. In 1902 Dr. Butler, Imperial Mycologist, observed a disease of ginger plants near Surat in the Bombay Presidency* identical with this one in Rangpur, and it has also been reported from Nadiad. He found *Pythium gracile* commonly in the diseased portions of the rhizomes and lower parts of the leaf sheaths, and this was the only fungus found in the interior of the stem in the early stages of disease. It was in most cases but not always associated with eelworms. This fungus was also invariably present in the ginger plants in Rangpur. Here, too, eelworms were often present even in slightly diseased parts but several examples were found with the fungus alone present, and it is believed to be the cause of the rot. Slabs cut out with a red-hot knife from the interior of stems that were only slightly diseased and grown under aseptic conditions gave pure cultures of *Pythium gracile* only. On dissecting many plants, examples were found that pointed clearly to the infection having come from the planted sets and this seems to be the method chiefly responsible for the introduction of the disease into the growing

* Memoirs of the Department of Agriculture in India, Vol. I, 1906. Pages 16, 68, 75.

PLATE XXIII.

Rhizomes badly diseased.

crop. Several cases were found where only a very small part of the current year's rhizome was diseased. Young buds still underground or just above ground were found to be diseased, the infected portion being isolated and extending inwards only a very short way. A connection was also traced between an affected shoot and an adjacent bud below ground that had been destroyed by disease. Under the microscope the hyphæ of the fungus were seen ramifying in the cells of the discoloured portion, and their tips extended into the living cells of perfectly healthy tissue. There is then little doubt but that this fungus is parasitic. The planted sets from which these affected buds spring were quite free from disease. They were not discoloured nor were hyphæ seen in section either in the neck connecting the old and new rhizomes or in the old rhizomes.

11. To make certain that the fungus *Pythium gracile* is the cause of the disease it is necessary to produce the disease in healthy plants after inoculation with a pure culture of the fungus. Such infections have not yet been carried out successfully. For this reason we cannot be certain that *Pythium gracile* is the cause of the disease. Still with the experience on the Rangpur farm, we are in a position to make the following recommendations to check the disease:

1. On harvesting the crop all the rhizomes should be removed from the ground. Diseased ones ought never to be left on the ground. They should be collected with as many of the roots attached as possible and burned or buried deeply in a place where ginger will not be grown. The shoots of diseased plants should also be gathered and burned.

2. Ginger should not be grown on the same land for at least three years. As there is plenty of available land, in Rangpur District at least, this should not be a difficulty.

3. The seed should be got from a place that is free from disease. Great care should be taken to ensure that the seed is healthy. Yet it is not always possible to recognise by the naked eye alone the early stages of disease in a rhizome. If any of the buds are bad the whole piece should be suspected and discarded.

4. Whenever disease occurs in a field, the affected plants should be dug out whole with the larger roots attached and should be destroyed by fire. It is not enough to pull the shoot off by the cellar. The rhizome must be got out too. By breaking the shoots off at the collar or by detaching the larger roots an opening is given for liberating the infection into the soil. Infected plants should never be thrown down in the field to rot but removed to the edge of the field and burned.

5. Water should never be allowed to lie or stagnate in a ginger field. Air and water should be able to move freely in the upper layers of soil, surrounding the tubers. Fortunately, as mentioned above, cultivation and drainage is well attended to, as a rule.

6. Till the disease has been further investigated, these precautionary measures will suffice to keep it in check. They have acted very well at Rangpur Farm, where in two seasons the amount of disease was materially reduced.

# TWO INSECT PESTS OF THE UNITED PROVINCES.

By T. BAINBRIGGE FLETCHER, R.N., F.E.S., F.Z.S.,

*Offg. Imperial Entomologist.*

THE very idea of such a subject as Economic Entomology is still such a novelty in the eyes of the Indian agricultural classes that little general progress has been made in the adoption of preventive measures against insect pests as part of the ordinary routine of agricultural operations. The life-history of even the commonest and most destructive insect is generally a closed book to the very class of men most vitally affected by their want of knowledge. The fact that a moth lays eggs may be known as the result of more or less idle observation, but that the moth and the eggs may have any relation to the caterpillars which presently swarm everywhere and devour the crops is, generally speaking, a matter undreamt of in the cultivators' system of philosophy. It is necessary, then, to start from the very beginning, to point out the damage wrought by insect pests and to devise simple methods of minimizing the damage done by them. It is very important to bear in mind that the remedies adopted, to be suitable to Indian conditions, must be simple and cheap; they must harmonize with the conditions of the local agricultural practices and must not involve the use of any expensive apparatus or insecticides. Granted that these conditions are fulfilled, it still remains to get the cultivator to apply the remedies for his own benefit, but, generally speaking, he is shrewd enough to make use of them once he is convinced of their utility. Occasionally some difficulty is experienced on account of a real reluctance to take life even in the case of insects avowedly destructive, but a certain measure of *vis inertiæ*, coupled with a natural suspicion of anything new, is commonly the greatest difficulty in the general adoption of more scientific methods.

There is little that is new in the following paper, which was prepared for and read at the Agricultural Conference at Allahabad in January of this year. It deals with only two pests, neither of which is confined to the United Provinces; on the contrary, both are distributed over nearly the whole of India, and the first (the Cane Grasshopper) does immense damage to rice crops in some districts. The main point dealt with is the necessity for co-operation and an appeal for this is addressed chiefly to those members of the landed classes who read these lines. We are willing and eager to help the agricultural classes throughout India to obtain the full benefit of their labours: the difficulty is the diffusion of knowledge owing to the scanty number of workers and the immense areas to be dealt with. What can be done with the present staff is being done, but still more can be accomplished if the larger land-holding classes will help in spreading a knowledge of the life-histories of insect pests and of simple preventive measures to be used against them.

The subject of the following paper is that of some insect pests of crops and the best methods of dealing with them. The agriculturist's ideal has been defined as the making of two blades of grass grow where one grew before. This may be the height of his ambition, but actually his end is to obtain a larger produce, crop, profit—call it what you will—from the ground. The aim of the entomologist is to help the agriculturist by seeing that he gets this increase and that his profit is not destroyed by undue toils levied by destructive insects on the crops before or after harvesting.

Every plant that grows is attacked by some insects, often by many, and it usually happens that the insects found on any particular wild plant are especially attached to that plant and will not eat any other. This fact is very important in considering the increase of such an insect, because of the difficulty of its finding a sufficient quantity of its favourite plant in one place. In the case of crops, this restriction is removed, so that an insect which feeds on a cultivated plant, such as sugar-cane or potato, finds abundance of its special food and in the absence of efficient checks is able to multiply until it seriously affects the yield of the crop, when we begin to speak of it as a pest and look around for the best means of combating its attack.

Now, the first point to be considered in dealing with remedies for a pest of this sort is the necessity for a knowledge of its life-history. If we know exactly when and where the eggs are laid, when they hatch, when the perfect insects emerge and, generally speaking, if we know exactly what the insect is doing at any particular time in any particular place, we then have the information which will probably enable us to put our finger on the weakest place in that insect's economy. This is the work of the entomologist, who makes it his business to recognise the insect, to know which insects are the most destructive and what are the best methods to use against them.

### The Cane and Rice Grasshopper.

The first insect pest which I shall deal with is the sugar-cane grasshopper, whose life-history is as follows :—

The eggs are laid as the land dries up after the rains, *i.e.*, at the beginning of the cold weather, and remain dormant in the soil until the beginning of the next year's rains. As soon as the rains commence and moisten the soil about the end of June, the eggs hatch out and the young hoppers make their way up through the soft earth.

The young hoppers on emerging from the egg are about a quarter of an inch long and of a greenish yellow colour. At first they feed on any tender vegetation which they find close at hand, especially small millets such as *sawa* (Panicum frumentaceum), *mandua* (Eleusine coracana), *kodon* (Paspalum scrobiculatum), and *kangni* (Setaria italica) gradually working their way along the ground away from the place where they hatched out until they come across a field of young cane, or some similar situation with an abundance of food to their taste. Here they gather, commence to feed and grow, although owing to their small size, the amount of damage which they do at this first stage is not so very great. It is not usually till the second or third stage that they are *able* to eat cane or that they do so. I would emphasise this, as they do not enter cane till the third instar usually. After about ten days they shed their skins and increase in size to about half-an-inch in length, and again shed their skins four more times at intervals of about ten days when they become fully-grown. Their growth may be shown thus :—

| Stage | Length (inches). |
| --- | --- |
| 1 (newly hatched) ... | [illegible] |
| 2 | [illegible] |
| 3 | [illegible] |
| 4 | 1 |
| 5 | $1\frac{1}{4}$ |
| 6 (winged stage) | $1\frac{3}{4}$ |

there being an interval of about ten days before the commencement of each succeeding stage. As the hoppers grow larger they require a larger quantity of vegetation to nourish them and the damage which they do consequently becomes greater. It must be noted that it is only in the final stage that the grasshoppers have wings, and it is in this last stage only that they are able to fly and to lay eggs and in this stage also they live longest (excluding the egg stage when they do no active damage) and do most harm. In this winged stage the grasshoppers are all alike in colour and appearance, but before they obtain wings they may be green, or yellow, or brown, although their usual colour is yellowish green. This is not the place to enter into a minute description of the insect in all its stages. You are probably all only too familiar with it, but specimens and coloured figures exhibited will show what it is like to any one who is not acquainted with its appearance.

The hoppers, after they have begun to grow a little, are very voracious and eat up all the leaf of a field in a short time, every part of the leaf except the midrib being devoured. By the time they are full-grown the great majority of them are to be found in the *Ukh* (sugar-cane) fields, this fact being probably due partly to their finding in these fields a large mass of vegetation suited to their taste and affording at the same time a certain amount of protection against insect-eating birds, and partly to the fact that by this time most of the *kharif* crops have been harvested. They are only active in the day-time, apparently feeding at intervals throughout the day, but chiefly in the morning. By night they are sluggish and inactive and do not seem to feed.

About the end of the rains the grasshoppers pair, lay their eggs and die, but the period of adult life may be protracted until quite late in the year. At Azamgarh in 1908, egg-laying took place as early as the end of August, whilst at Pusa all the grasshoppers are usually dead by the middle of November, although during 1910 many were still alive in the middle of December. As a rule, however, egg-laying takes place in September or October. The eggs are not laid at random, but, on the contrary, the female exercises great care in choosing a suitable locality, carefully examining the ground and, if no suitable place is found, taking long jumps in search of another likely spot. Having finally satisfied herself of the eligibility of the site selected, the female raises herself on her legs and bends down her abdomen until its tip touches the ground and proceeds to bore a hole which goes straight down for about two inches into the soil. As soon as the hole is ready the female lays her eggs at the bottom of it, the eggs being laid in packets about $\frac{3}{4}$ inch in length and containing some 20—30 eggs. When first laid the egg mass is covered with a gummy coating which is quite soft but soon hardens to form a protective covering to the eggs. About four lots of eggs are usually laid by each female, which then dies almost immediately afterwards. The hole in which the egg-mass has been laid is sometimes filled up with earth by the grasshopper, sometimes left open ; in any case, it is impracticable to find the egg masses by mere inspection of the ground without actually digging it up.

Looking at the life history of the grasshopper, we see that it divides up into two distinct periods, which are, roughly speaking :—

(1) Mid-June to Mid-October when the grasshoppers are actively employed in eating the crops.

(2) Mid-October to Mid-June when the eggs are lying dormant in the soil and no actual damage is being done.

During the first period, *i.e.*, during the rains, we can fight the grasshopper by dragging bags over the young crops and then killing the insects caught in this way. This method, however, is not within the reach of the small cultivator, simply because he is quite unable to meet the extra expense of even so simple a contrivance as a bag. There is, however, one method which he may adopt at this time of the year for what it is worth, and that is the encouragement of insect-eating birds by the erection of a few suitable resting places for them amongst the crops. In the Agricultural Court of this Exhibition is shown a collection of some of the commonest of the birds of India, and every one of these birds has been assessed at a certain value based solely on a careful consideration of the question as to whether or not it is of benefit to the cultivator. An inspection of these birds and of the specimens of insects (also exhibited) will show which birds are actually useful and therefore to be encouraged and even the most poverty-stricken cultivator can at least try to attract the birds to help him by putting up branches and so giving them perches to rest on.

But it is during the cold weather and in the hot weather before the rains begin that the grasshopper is most open to attack. During the whole of this period of seven or eight months the eggs are lying in the soil, only a couple of inches below the surface, unable to move, helpless and positively inviting us to assume the offensive and prevent their hatching and doing us any damage. The measures to be taken are quite simple and merely consist in ploughing up the soil about March and so exposing the egg-masses to the light and heat of the sun. The best thing to do is to plough up the land in those tracts where it can be ploughed with an iron plough immediately after the crop has been harvested in March and to plough it over again three weeks afterwards. If an iron plough cannot be used, a country plough will be better than nothing, but it must be borne in mind that the end to be accomplished is the thorough turning up of the soil and the consequent exposure of the egg-masses to the sun. The old *ukh* roots must be dug up and burnt before the ploughing takes place. A large number of the egg-masses will be found under and amongst the roots and they will thus be exposed and killed and the burning of the roots and stubble will help to prevent the increase of other injurious insects which live there. There is one point about these egg-masses which deserves mention and it is this: it has been noticed that the grasshoppers attack one crop of cane or rice in a village after another and that they lay most of their eggs in the fields which they attack last. By noting the fields in which there were most grasshoppers about September and by making a few trial diggings in these fields in the winter, the fields which contain the majority of eggs can probably be ascertained and these fields especially dealt with by ploughing in March. The eggs are probably laid in whatever fields the grasshoppers are feeding in at the egg-laying period (about September), but in the case of crops of *sawan*, *mandwa*, etc., the egg-masses are probably destroyed to a large extent by the disturbance of the soil consequent on the cultivation which follows in the succeeding *rabi*. The cane *peri*, however, is usually allowed to lie over and the eggs in these fields are consequently not disturbed until they hatch out. Once again therefore I would urge the importance of rooting up the old *ukh* stumps and of thoroughly ploughing up the *peri* immediately the cane has been harvested.

Other methods of less importance which are worth carrying out are the constant grazing of cattle especially on fallow lands in the vicinity of cane fields, and clean cultivation around the crops themselves (on field embankments, etc.).

The damage done by the grasshopper may also be lessened by growing Borakha *ukh* as far as possible. This variety is comparatively a much harder food, less attractive to the grasshopper than the *mango* variety and grows up quicker. It is not, however, in favour with cultivators as the yield of sugar is considered to be less.

Finally, in considering the damage done by this pest and the best means of lessening it, there is one point that must be insisted upon, and that is *co-operation*. It is most important that a cultivator should have sufficient knowledge, sufficient forethought, and sufficient energy to do all that lies in his power to protect his own crops by destroying the eggs before they hatch and by using every endeavour to destroy and harry the hoppers after they have emerged from the egg, but this is not enough: he should use every endeavour to induce his neighbours to do the same: otherwise, the eggs will hatch out in *their* fields and after destroying *their* crops, will invade *his*. If all the cultivators will agree to join in and work together, a great deal can be done and all their crops will benefit: but if only a few fields are left untreated, the grasshoppers will hatch out there and spread out thence to infest the surrounding areas.

## THE POTATO MOTH.

The other insect pest to which I want to draw attention is the potato moth and the best means of storing seed-potatoes.

The potato moth, although well-known in America, Europe and Australia seems to be a fairly recent arrival in India. It has been suggested that it was first imported in seed-potatoes received from Italy, and this is possibly true: the fact, however, remains that the moth has now obtained a firm footing in India and is steadily spreading into every district where potatoes are grown. In some cases we can say definitely that the moth has now invaded localities which were free of infection a few years ago. Much of this infection of new areas is undoubtedly caused directly by the importation of infected potatoes from one district to another, and with the present large consumption of potatoes for food it is practically impossible to prevent the spread of the moth in this way.

The moth itself is a very small greyish-brown insect, which can be seen flying about the potato-fields or sitting on the stored potatoes. The caterpillar can feed on the leaves or shoots of the growing potato-plant or inside the potato itself. It is when it is feeding in the potato that it does most damage and is most liable to be carried into fresh districts. A whole life-cycle of the pest, from egg to moth, may take as short a period as four or five weeks, and as each female moth may lay upwards of 100 eggs, the increase may be very rapid. Assuming each female to lay only half this number of eggs, then if the whole progeny of a single female survived, they would total very nearly twenty millions (two hundred lakhs) in the fifth generation, that is to say, after five or at the most six months. In actual practice, of course, the moths do not increase at this rate, but it will readily be seen that their rate of increase may be extremely rapid under favourable circumstances, so that a very small quantity of diseased potatoes introduced into a new locality will quickly infect the whole area. The pest being one that has been introduced into India, the conditions for its rapid increase are unfortunately only too favourable, as none of its natural enemies in the shape of parasites appear to have been introduced with it, so that the only real check on its increase is the quantity of food which is available. So far as we are aware at present the caterpillar feeds only on potato in India, although in other countries it has been found to feed on various species of *Solanum* and also on the tomato (*Lycopersicum esculentum*) and on the tobacco plant.

We cannot in practice prevent the caterpillar from feeding on the growing potato-plant; spraying would be useless, as the caterpillar is a miner inside the leaves and shoots. In these provinces, potato is grown in the cold weather when the pest is comparatively inactive so that damage to the growing plant is not important. But we can prevent it from mining our seed potatoes which are being kept to sow for the next harvest. Experiments made at Pusa and carried out on a practical scale in the Central Provinces have shown that it is possible to keep potatoes free from the moth during the period between April, when the spring crop ripens, and September-October when the autumn crop is sown. Full details of these experiments will be found in the Agricultural Journal of India for January 1910.

Briefly speaking, the method aims firstly at killing any eggs which may have been laid on the potatoes; and secondly, at protecting the potatoes from any further attack by the moths. The potatoes are steeped for five minutes in a solution of Crude Oil Emulsion prepared by simply adding one pint (one and a quarter pounds) of Crude Oil Emulsion to four gallons (one kerosene oil tin full) of water and stirring the mixture with a stick. After steeping in this, the potatoes are taken out, dried, and stored under sand which must be quite dry but not hot. The oily mixture kills any eggs which may be on the potatoes and the covering of sand effectually prevents the moths from laying their eggs on them again. The potatoes must be examined about once every month whilst they are so stored and any which may have rotted, picked out and destroyed. The actual loss of seed-potatoes during the monsoon after treatment in this way is usually about one-third to one-half of the original weight. But it is to be noted that, before the potato moth was known at all in India, the loss of seed-potatoes during the monsoon was generally reckoned at about one-third, due to attacks of fungi, etc., during the damp weather, and to loss of weight by simple drying.

The method of treatment with Crude Oil Emulsion was devised especially for the treatment of potatoes reserved for seed for the next crop, and objection has been raised that the use of the crude oil imparts a disagreeable taste to potatoes intended for eating purposes. If this is found to be so, the use of the oil may be omitted, *but only in the case of potatoes not intended for seed.* When the potatoes are dug, the tubers are, or should be, free from the moth which up to then has been feeding on the parts of the plant above ground, and if the tubers are dug in dry weather (which is the case of those taken up in April and May) and *immediately* stored under dry sand, they should remain free from the moth.

As soon as the crop is dug, the tops of the plants should be collected and carefully *burnt* to destroy any moths which may be in them and great care must be taken, when rejecting diseased and rotten potatoes from the store, that all such are carefully and thoroughly destroyed. If the potatoes in store are covered with sand so that the moths cannot get at them to lay eggs, and all other food in the shape of haulms and rejected potatoes is carefully destroyed, there is some hope that the pest may be starved out, or at least kept within reasonable bounds. The difficulty has been to find a method of storing which will prevent the moth getting at the tubers : if the tubers are kept in a closed box for instance they rot and only after trying 40 different ways it was found that storage in dry clean sand prevents the moth laying eggs and at the same time does not induce rot.

But, just as in the case of the cane grasshopper, one of the most important things is co-operation. If everyone works together, protects his crop from attack in the manner outlined above, and keeps his potato fields and his potato-store clean and free from stalks or rejected potatoes where the moth may be able to go on breeding, it may be possible to do a good deal against this pest and to keep it more or less under control, but a single neglected field or dirty store-house may prove a centre of infection or re-infection for the rest of the village or the surrounding neighbourhood.

The potato moth is not known in all districts, it has probably quite recently entered Lucknow with seed from Patna.

We would urge most strongly the very great importance of not getting seed-potatoes from any infected area : the whole of Bombay, the Central Provinces and Bengal is infected : a great part of the United Provinces is apparently not, and the pest does not seem to have reached the hills, so that uninfected seed-potatoes can be obtained.

We have discussed here only two pests, one indigenous to the province, one quite lately spread. In so far as the staple crops are concerned, there are probably no other pests lately introduced whose spread can be stopped, but there are plenty which are indigenous and which cause loss. There is not time now to discuss these : they are known by experience to all cultivators and we hope to be able to help to check them ; but there is no reason why cultivators should not themselves take an interest in them and find methods of checking them ; it is quite certain that they cannot in this country apply expensive and difficult methods such as spraying to all crops or to most of them, nor can any one devise a medicine or poison that will keep insects off or kill them. What they do must be simple and cheap ; it must be based upon a knowledge of the insect and its habits, and of the local agricultural practice. In these provinces there is a high standard of agriculture, but while great attention is paid to cattle, to seed and to ploughs, none is paid to insect pests. It is quite easy for cultivators to understand how their insect pests live, and if they knew that, they would be far better able to devise remedies for them than we can. They probably think this is a very difficult matter, and that only by deep study can they know how insects live and breed ; but I assure them that it is a simple matter to understand once it has been studied : we do not expect them to study it ; we do that ; but just as we have explained quite simply above how two of their pests live so they can know quite simply about others. We would urge them to take an interest in this subject, and we have tried and are trying to spread knowledge of insect pests and their habits. In the Exhibition are shown the chief pests of the province ; books, leaflets and articles have been and are being published, cultivators can get full information about pests : if we cannot in all cases give them direct remedies it is because we cannot from a distance understand the agricultural conditions of all districts and this is as important as knowing how the pests live and breed. There are probably very few cultivators who know even that a moth lays eggs, which become caterpillars, which then enter a resting stage before they come out as moths. If all agricultural people knew even that, we should be a very long way towards getting an interest taken in pests and in methods of checking them. If they want to get help in checking their pests, the borer in the *juar* (*Andropogon Sorghum*) and cane, the boll-worm in the cotton, the aphis (*tela*) in the mustard, the leaf hoppers in the mango blossom, the white bug on the mango shoots, etc., they must realise that it is essential that they and all agricultural people should know something of them and their habits, and landowners as the leaders of the community should stimulate this and give us, who are trying to help, the assistance and co-operation that are absolutely essential.

# CAMBODIA COTTON IN INDIA.

By P. VENKAYYA,

*Superintendent of Farms, Munagala Estate, Jabalpet.*

(Reproduced from the "*Indian Textile Journal*" *of 10th June* 1910.)

THE Honourable Sir V. D. Thackersey, as President of the second Industrial Conference at Calcutta, remarked: that "the reason why the Indian millowners have to restrict themselves for the production of coarser sorts of cloth is the quality of cotton grown in the country at present. So long as cotton of superior staple is not produced here, it is hopeless to expect the manufacturer to improve the quality of his cloth. . . . . . . . If the country gives the Indian manufacturer a superior staple cotton, there can hardly be a doubt that he will be able to supply the needs of the people from his looms. . . . Then will be the time for the full realisation of the *swadeshi* ideal in respect of our clothing. Until then for superior varieties of cloth we must depend on the foreign producer."

It is to solve this problem of "finding out" a long-stapled cotton which may be universally grown in place of the inferior varieties of short-stapled cottons which are now raised all over the country that an experimental cotton farm was started by the zemindar of Munagala in Kistna District (Madras), which is working for the last two years. About eleven varieties of cottons have been tried, six of them being among the most important cottons of the world. They are the famous Sea Island cotton of the United States which stands to-day unequalled on the cotton market, the Egyptian cotton which is supposed to have been originally the same as the Sea-Island but altered by cultivation and climatic conditions in Egypt, the "Caravonica" cotton invented by Dr. Thomatis of Queensland in Australia who produced it by crossing the Sea-Island and Pernambuco cottons, the "Spence tree cotton" about whose excellence many columns appeared in the journals of Western and Northern India, the "kidney cotton" which is specially valued for its rough stapled lint, and the "Cambodia" cotton, a native of the Indo-Chinese Peninsula, which is a hardy and long-stapled annual, yielding lint of a superior white colour. Out of these, the Sea-Island and Caravonica cottons being plants which require the influence of the sea to a great extent did not give any satisfactory results. The Egyptian cotton which requires a very high standard of cultivation and copious irrigation, both of which are a little above the means of the ordinary cultivator of this Presidency, did not also take kindly to our farm soils. The "kidney cotton" became very herbaceous and yielded little in the first year, whereas the Cambodia cotton gave very excellent results. The following report on Cambodia cotton from the Bombay Chamber of Commerce, which is perhaps the highest authority on cotton questions in India, will clearly show that this hardy long-stapled cotton possibly would ultimately revolutionise the cotton cultivation of India :—

*Bombay, 11th May* 1908.

"I am directed to acknowledge receipt of your two letters together with a sample of Cambodia cotton and in reply to forward you the following report on the latter :—The sample is 'kapas,' *i.e.*, the seeds have not been extracted. In order to make the cotton marketable it will be necessary to gin it. The cotton is very white, long stapled, about 1¼ inches staple, with fine strong fibre. *It is the best cotton the reporter has ever seen grown in India except tree cotton.* Its value to-day, properly ginned and packed in bales, would be about Rs. 270 per candy, Broach being only Rs. 225. It can be used up to 32's warp and 50's weft. At the above-mentioned price all the cotton that can be possibly produced could be disposed of with ease, if properly ginned and delivered free of charge at the Wari-Bunder Railway Station. ......

(Sd.) J. B. LESLIE ROGERS,
*Secretary.*"

Again, the famous firm of Messrs Tata Sons & Co., of Bombay, in a letter, dated 19th March, 1908, says: " . . . The colour of this cotton is very good being purely white. The staple is long and tolerably strong. We value it to day at about Rs. 270 per candy.

Yours faithfully,

(Sd.) TATA SONS & Co.

The Deputy Director of Agriculture, Northern Division, who was deputed by the Director of Agriculture, Madras, to inspect our Cambodia cotton and furnish a report on it made the following remarks in his report:

"The introduction of Cambodia cotton into the Munagala Zemindari appears to have every chance of success. . . . . Of these No. 1 Cambodia was growing well. The prospects of Cambodia are promising . . . . . . ."

## I. CLAIMS OF THE CAMBODIA COTTON.

Now, the superiority of Cambodia cotton over all the Indian grown cottons and the advisability of replacing them as far as possible by Cambodia cotton can thus be clearly understood by a reference to the above letters. It should be borne in mind that the price of a candy of Cambodia cotton is Rs. 270 and an acre of land produces one candy of cotton on an average. The cotton is dead white in colour, the staple is fine, silky and 1⅛ inches long. What can the apathetic *ryot* desire more? Nature would seem clearly to have devised this tree to meet the present crying need for long-stapled cotton in India. The quality of this cotton is so excellent that it opens an entirely new field for Indian manufacturers, the importance of which, bearing greatly as it does upon the future prosperity of the country, cannot be overestimated. The great advantage and importance of Cambodia cotton is that it is practically a hardy annual, but not a perennial, for perennials are always greatly subject to insect pests—that it is sown exactly at the same time when all the country cottons are sown, and also ripens just within the same period like the rest of the Indian cottons, that it requires no irrigation, and the treatment it requires is also just the same as that given to any other cotton at present cultivated in the country, that it will also grow and flourish practically in any soil in this country on which the ordinary country cottons will grow and flourish, and that it also fetches a fairly higher price to the impoverished *rayat* than any other country cotton. At the same time it also solves the problem of long-stapled cotton for the manufacturer. These are the claims of Cambodia cotton over the Indian cottons.

Now, for the information of agriculturists who wish to introduce Cambodia cotton into their lands, I wish to state that seed sufficient for one acre will be supplied on payment of Rs. 5. No order for below one acre of land will be complied with. One *ciss* of seed is generally sufficient for one acre, and this is the minimum quantity supplied. Orders for less than one *ciss* cannot be attended to. Intending purchasers should apply to me at Jalalpet, Masulipatam. Applications should be made before the 15th of August every year. The sowing season commences after the 15th of August every year.

## II. A Brief Account of this Cotton and the Method of its Cultivation.

Cambodia cotton is a native of the Indo-Chinese Peninsula. Black cotton soils and sandy loams are the best soils for the propagation of this annual cotton, that is, it grows readily on the soils that are generally allotted for the cultivation of the [illegible] cottons. As soon as the rains set in, the ground should be thoroughly ploughed four or five times and lines formed two and a half feet apart. In these lines or furrows the seeds should be sown two feet apart when there is sufficient moisture in the soil for the seed to germinate. The seeds should be rubbed thoroughly in cow dung and earth prior to sowing. This not only keeps the seeds free from lint and other material to facilitate sowing, but also helps germination to some extent. As soon as the germination is complete the field should be gone through and any blank spots resown. The after-treatment which the ordinary short-stapled cottons receive at the hands of the local *rayat* is also enough for this exotic plant.

### III.—Time of Sowing.

The middle of August is generally the best time for sowing. The plants begin to flower in their third month, but bearing does not take place till the beginning of the fifth month. The plants go on bearing for three months continuously. The cotton collected from the first picking is generally considered to be very good. So, care should be taken not to mix it with the cotton collected during the latter pickings. The cotton from the second picking is not so bright as the first, and it should, therefore, be kept separate. If, by mistake, all the pickings are mixed together, the buyer will only offer the price of the lowest grade. It may sometimes so happen that two or more varieties of cotton may be standing side by side in a field. In this case care must be taken not to mix one with the other during the picking season.

### IV.—Irrigation.

Like all the local short-stapled cottons, this variety needs no special irrigation. On the other hand, it must be distinctly remembered that a thorough drainage is quite necessary for this or any other variety of cotton plant. If water remains stagnant at the roots of the plants, danger is imminent.

### V.—Time and Method of Picking.

As soon as the capsules are well open all over the field picking should at once commence before the cotton begins to fall on the ground. The best time to commence picking is generally in the morning. The picker should hold the boll firmly with the left hand and remove the seed-cotton with one pull by the right. If he takes two pulls he will only get half the amount picked per day. Cotton should always be picked when the boll is fully opened. If it is picked before the boll is quite ripe the cotton is brittle and does not fetch a good price. The most important point, however, in picking cotton is to see that in extracting the "seed-cotton" from the boll nothing like bits of dry leaves, trash, etc., should adhere to it. If anything should get attached, it must be picked off at once. The reason is, if the cotton to which the trash is attached is put into the bag with other cotton, the trash becomes pressed into the lint and it is very difficult to remove it afterwards, the labourers often breaking the fibre in removing it. Care should also be taken not to mix discoloured or unripe cotton with the good produce. One of the chief reasons for the low prices paid to the Indian cottons in the foreign markets is careless picking. Leaving cotton in the field after it is ripe also causes it to deteriorate. Cotton left exposed to the weather becomes stained and loses its strength rapidly; consequently cotton so treated must prove of poor quality.

## VI.—Cleaning and Drying.

As soon as the cotton is picked it should be sunned until it is thoroughly dry. While it is being sunned, stained cotton or immature bolls should be removed, and at the same time any cotton that has fallen to the ground and got earth and sand mixed up with it should be "whipped" so as to have it perfectly clean before it is sold or sent to the gin.

## VII. The Importance and Necessity of Seed Selection.

It is absolutely necessary to select good seed. A good crop cannot be obtained from a doubtful stock nor can good stapled cotton be produced from an inferior variety of seed. In the Western countries there are large numbers of trustworthy seed merchants whose existence depends upon being able to supply choice seeds of every kind of crop. In this country seedsmen in the ordinary way are non existent, so that each cultivator is thrown more or less on his own resources for the supply of seed for the various crops. Cotton is the crop in which we are at present most interested, but the methods to be described are applicable to every crop under cultivation. For the production of high quality and big yields, failure can be the only result if the best seed be not sown, no matter how good the cultivation or liberal the manuring. In the selection of seed for cotton we have two primary objects in view, *viz.*, to obtain the greatest yield and the best quality. To select for both objects at the same time is quite possible, though we think that the main object in view can be accomplished by growing in the first place the very best seed obtainable and then selecting seed from the heaviest yielding plants, provided the quality of those plants is equal to the best standard of that variety. In the system of selection adopted by the Sea-Island planters in America most distinctive results have been obtained. For example, one grower's ideal has been to obtain heavy yields with but a secondary regard for quality, and this has been quite successful, the grower's cotton being known in the market as that from heavy yielding plants, but whose quality is not "extra." Another planter again has selected for quality only, and though yield has been to a certain extent sacrificed, yet his cotton is sold for a much higher price. Thus starting with the same seed, two different ideals may be reached according to the wish of the particular grower. As a rule, however, our primary object is to increase the yield, and while striving to obtain this we have to see that we do not sacrifice quality and other desirable characteristics, but keep them at least up to the best standard. An area of the variety chosen should be planted with the best seed obtainable, and should possess a good soil and be thoroughly cultivated and manured in order to obtain a good development of the plants, and consequently ideal conditions for making selection. Just before the first picking, when some of the lower bolls are well open on all of the plants, the field should be gone over and every plant examined with reference to productiveness, number and size of the bolls, vigour and shape of the plant, early ripening, etc.

Ample proof has been given over and over again that in any particular district seed can be produced by selection, which for vitality, immunity from disease and crop producing qualities far excels that of any variety suddenly dumped down from outside sources. Below are some of the methods generally adopted for improving cotton, many of which can be easily carried out by even the uneducated *rayat* :—

Reserve the best part of the crop for seed. This can be generally done by reserving a certain area for seed purposes and giving it full opportunities for good development and the resulting crop is kept back entirely for the next season's sowing. Another method, no less commendable, is to go over the growing crop and note any particular areas of great promise. The seed from the selected portions is carefully set apart for next year's crop; but neither of the above is sufficient if we wish to progress on the right lines. For example, if we wish to develop a variety of cotton which above all its other qualities, must be an early ripener, what system should we adopt to attain that end? We must collect the early ripening bolls, and after ginning this cotton by itself reserve the seed for propagation of the crop. That this is sound and efficacious has been demonstrated times without number. Perhaps the best object lesson in this respect is to be found in a careful study of Sea-Island cotton which to-day stands pre-eminent. Long ago when cotton seed was first introduced into that district in America, it failed to give a crop in the first season. The plants died down, but, in the spring of the next year, grew up and managed to ripen a few bolls before the end of the second season. The seeds from these were again planted with great care. The method was assiduously followed up until to-day we find the Sea-Island cotton ripening its crop in one season. And not only so, but, in the meantime the length, strength and fineness of the product have been enormously improved, so that nowadays it is unequalled in the market.

Another important point to be remembered in the selection of seed is the keeping back for seed purposes of the biggest and best developed seeds from the whole crop. It to some extent ensures that the seed contains a supply of nourishment sufficient to give the young plant a good start in life and to tide it over any early struggles for existence.

Spontaneous types or sports frequently occur in plant life. These differ greatly from the surrounding plants and if the qualities of the product are in any way superior the type should be propagated and tended until it becomes fixed. Sports result chiefly from natural crossing in the field or from the influence of the soil, climate and cultivation on that particular plant. In one of the villages of this Zemindari I have come across a kidney cotton tree, the seed of which, much unlike the seed of its family, is green like a leaf. We have preserved the seed of this plant and the matter is under investigation.

A still more comparatively simple method of selection which could be undertaken by every one is as follows :—

Select the best looking plants for seed purposes.

Reserve only the best developed seed.

Select the earliest ripening bolls for seed.

Select the plants which flower at first.

Select the plant which bears very heavily.

Select the plant which yields the biggest bolls.

Select the plant which gives a very white lint and a long staple, combined with a smooth and silky texture, and a uniform fibre which will withstand a fair strain in testing its strength.

It is desirable to mark more plants than are expected to be used, because in going over and comparing the plants the first time, it is ordinarily found difficult to carry the characters desired in mind with sufficient accuracy to enable a careful judgment to be made. Therefore some fifty of the plants should be first marked and numbered, so that these can be more carefully examined a second time and the number reduced probably by one half or more. The permanent numbers should be placed only on the plants which are finally selected. Before each picking an intelligent man should go over the field and pick the cotton from each plant in sacks numbered to correspond with the numbers on the plants in order that the different pickings from the same plant may be kept together. Later on, after the close of the picking season, the seed-cotton from each individual plant can be more carefully compared and weighed and any of the plants which are found to have fallen below the standard of production, or in any other important feature, should be rejected. The remaining should be ginned, care being taken to have the gin thoroughly cleaned out before beginning the process, so that the seed from the selections will not become mixed with ordinary seed. After ginning each individual plant, the seed should be carefully picked up and replaced in the numbered sack, so that all of the seed from the same select individual will be retained by itself. In this connection I think it will not be out of place to say something about the mixing of seed in general. Mixing of seed can easily take place either at the gins, or in the riddles where the seed is separated if required for sowing purposes, the small and broken seed being rejected. Thus, after one variety of cotton has been through the machinery, unless great care is taken to clean up all the seed, mixing follows when the next kind is being dealt with. Such is the case in all large ginning factories where different varieties of cotton are dealt with. So the practice of purchasing seed for seed purposes from the ginning factories must be discouraged as far as possible. The ideal condition for each cultivator is to hand-gin his own seed for seed purposes.

These few instructions will, I hope, help those who wish to undertake the cultivation of this cotton. I will be only too glad to furnish any further information required in connection with the cultivation of Cambodia cotton. I have already pointed out that my wish is to disseminate knowledge of this cotton as far as possible in order to secure the cultivation of this long-stapled cotton all over the country.

# NOTES.

Paddy Seedlings Experiment.—An interesting experiment has been conducted by Mr. E. S. Baldwin, Deputy Magistrate, Darbhanga, to test the possibility of transport of paddy seedlings for considerable distance by cart and rail in time of famine. In conducting the experiment the seedlings were plucked from the nursery, then kept one day in a cart in the open, three days in a railway truck closed, and once again for a day in a cart. The conclusion arrived at by Mr. Baldwin was, that with proper treatment about 7/8ths of the seedlings will survive and be fit for transplanting at the end of the period mentioned above. The conditions under which transport should take place are given by the experimenter as follows:

"It is necessary that the day previous to the loading in the railway trucks, the paddy seedlings should be freshly plucked, tied into small bundles (*antis*), and then loaded on to carts after being freely sprinkled over with water. The watering should be carefully supervised, as natives are fond of washing the roots and thus removing the soil attached thereto. This should not be allowed. The seedlings will last longer if the soil is allowed to remain.

"On loading into the railway trucks the seedlings should once more be watered, but not to excess, as one result of the experiment has been to show that if too much water is poured over them, they are liable to wither away, owing to the heat given out by the seedlings themselves, combined with the heated and rarefied air inside the truck. The best method in order to safeguard the seedlings from being watered to excess, would be to employ gardening water cans fitted with the sprinkler if handy. This method would save time and trouble.

# PLATE XXIV.

C. J. T.

Front view of case prepared for Exhibition. Packing materials go out of sight behind false panel (under drawer in middle units).

"The experiment has further shown that a great deal depends on the manner in which the seedlings are loaded into the railway vans. It was found that those seedlings, which had been loaded standing upright (roots downwards), one above another, in two, and even three layers, were in a far fresher condition, and lasted longer than those seedlings loaded lengthwise on the floor, one above another. If loaded in the former manner, *i.e.*, standing upright, the seedlings will be in quite good condition and fit for planting on the fifth day after the plucking of same, and may possibly last to the sixth day, though the earlier the better.

"The simplest method of packing the seedlings standing upright in the trucks, would be to make one big bundle of 12 to 15 small bundles (*cutis*) tied together, though, in order to ensure their keeping good, the small bundles must on no account be tied together tightly, but may with great advantage be given what is generally termed 'breathing space.' The big bundles should be tied with stems and not with ropes if possible.

"On the seedlings being taken out of the railway truck for despatch to the necessary centres, they should once more be subjected to a watering, and then placed on the carts."

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NOTE ON AN EXHIBITION CASE.—The following note gives a brief description of a portable Exhibition show case which was designed specially for the use of the Department in sending exhibits to agricultural and cattle shows. It is proposed to keep at head quarters ready prepared classes of exhibits suitable to the district in which the exhibition is to be held, so that the case may be prepared with the least trouble and at the shortest notice. It is hoped that the ideas embodied therein may be useful to other departments.

The idea throughout has been to make the case attractive in appearance, light, rigid, and at the same time easily put together. It is made throughout of deal, polished black and picked out with gold. The one illustrated was made in Madras by a local carpenter and cost Rs. 200 complete but without the tin cases. These are enamelled green and were also made in Madras at a cost of Rs. 1-8-0 a-piece. The total cost has thus come to less than Rs. 300.

From the plans, the construction will be easily made out of the three units, the centre one and the right hand one fold together, while the left hand one which is attached by thumb screws, packs above them, the whole being then fitted into a crate. The projecting portion of the central unit consisting of a sloping glass desk with drawers beneath, rests on two opened panels, the space beneath being filled in with a false panel. The shelves are throughout adjustable, except those in the lower half of the side units which fold flat when not in use. The projecting frames are hinged on to two slats which are screwed to the side of the case; they pack separately and can be used or not as desired.

The tin cases open at the top, and can be made to hold samples of grain, cotton, fibre, manures, soils or anything else it may be desired to exhibit. Diagrams, maps, or plates, *e.g.*, of insect pests can be conveniently fastened to the side frames. The glass desk in front contains a tray which can be lifted out and could easily be fitted to show living silk-worms, or specimens of particular products or manures to which it is desired to give greater prominence. On the flaps of the side units will be found room for bulletins, pamphlets, calendars and other printed matter. (R. CECIL WOOD.)

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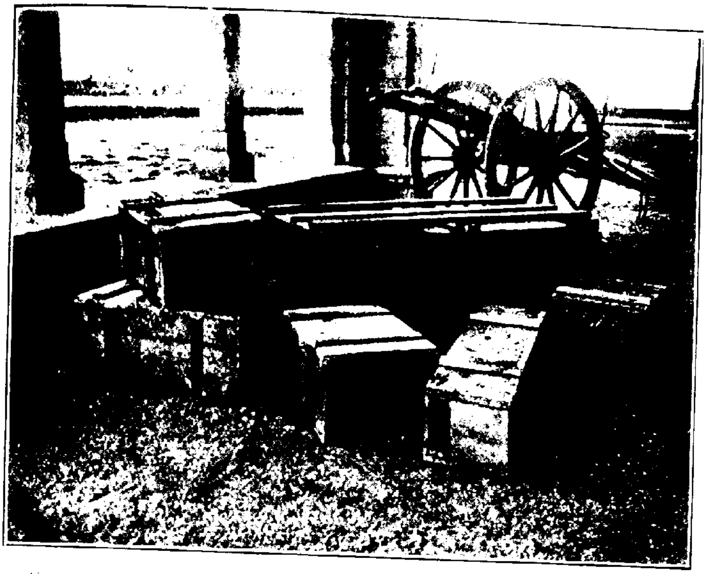
THE BAMBARRA GROUNDNUT.—The Bambarra groundnut (*Voandzeia subterranea*) is cultivated throughout Tropical Africa from the Sahara to Natal. It is a leguminous plant, in habit somewhat similar to the ordinary groundnut (*Arachis hypogaea*) but differing from it in that it has a lesser development of leaf system, and in that it forms its fruits around the principal stem and at a very small depth in the soil. This last characteristic of the Bambarra nut gives it a superiority over ordinary groundnut in so far as the harvesting of the former is much more easily

# PLATE XXV.



CABINET PACKED READY FOR TRANSIT. THE LARGE CRATE CONTAINS THE THREE EMPTY UNITS. IN THE OTHER BOXES ARE PACKED THE TIN CASES AND THE OTHER FITTINGS.

[illegible] THE CASE LOADED ON CARTS.

done than that of the latter. To harvest the crop, the stems are pulled up when nearly all the nuts adhere to them. The fruit is very like that of the ordinary groundnut, but is shorter, contains only one seed at maturity and possesses a prominent ridge which is absent in the fruit of *Arachis hypogæa*.

In Bulletin No. 21 of the Station Agronomique, Mauritius, it is stated that the requirements of the crop are the same as those of the ordinary groundnut. It is planted and harvested at the same time and in Mauritius is found to be a useful crop for cultivation between the rows of sugarcane. When so cultivated, it is sown in small pockets between the rows at distance of about 18" apart both ways, three or four seeds being put into each pocket at a depth of about 1 inch.

The nuts are collected when the leaves begin to dry up. The yield is said to be at least equal to, and generally greater than, that of ordinary groundnut. Cultivated in the above way between rows of sugarcane, a yield of 960 kilos. of green nuts and 3,120 kilos. of green leaves have been obtained per *arpent* (1·043 acres). The green nuts usually lose about 50 per cent. of their weight on drying.

The composition of the dried nuts, as determined at the *Station* Agronomique, Mauritius, is shown in the following table:—

| | Green. | | | Dry. | | |
|---|---|---|---|---|---|---|
| | Nuts. | Shells. | Entire nuts. | Nuts. | Shells. | Entire nuts. |
| Water | 45·40 | 17·96 | 63·36 | 10·27 | 2·00 | 12·27 |
| Ash | 1·28 | 0·18 | 1·46 | 3·23 | 0·71 | 3·94 |
| [illegible] | 2·35 | 1·23 | 3·58 | 4·63 | 5·23 | 9·86 |
| [illegible] | [illegible] | [illegible] | 2·43 | 5·03 | 0·14 | 5·17 |
| Sugar & Starch | 21·49 | 2·06 | 23·55 | 46·80 | 8·60 | 55·40 |
| Albuminoids | 5·67 | [illegible] | [illegible] | 12·04 | 1·32 | 13·36 |

With respect to the relative demands on the plant food of the soil it has been ascertained that the Bambarra nut requires a little less phosphoric acid, but much more potash than ordinary groundnut. Its nitrogen content, however, is always less.

The nut constitutes a complete food in itself. It may be used either for human consumption or for stock, while the leaves are useful either as fodder or green manure. When the ripe seed is ground, it is said to produce a very white meal from which excellent broths and soups may be made.

The main advantage of this plant over *Arachis hypogaea* seems to be that it can be harvested with much less trouble and at considerably less expense. As the cost of harvesting groundnut is proving an obstacle to its cultivation in parts of India where the labour rate is high, the possibilities of the Bambarra nut seem worth while experimenting with in such parts. (A. McKerral.)

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Indian Textile Fibres. The *Indian Textile Journal* for November, 1910, contains two interesting notes on Indian Sunn hemp and *Calotropis gigantea* which may prove of some importance to those interested in the Indian fibre industry.

(1) *Sunn Hemp.* -Ten samples of Indian "Sunn" or "San" hemp (*Crotalaria juncea*) were examined recently by the Imperial Institute, London. They had been grown in the Pabna District of Eastern Bengal and Assam. An account of the cultivation and preparation of Sunn hemp in that District is given in the *Agricultural Ledger*, No. 7 of 1908-09, which includes the results of the present investigation. The area devoted to this crop in the Pabna District is almost entirely situated in the Serajganj sub-division and the total annual production of the fibre is estimated to be about 5,000 tons. The ten samples of fibre received at the Imperial Institute were regarded by commercial experts as worth from £18 to £25 per ton. The experts to whom the samples were submitted confirmed the conclusions, deduced from the results of the chemical examination, that these fibres were of remarkably good quality. They were also particularly satisfactory in respect of length, strength and colour, and would find a ready market. Several of them were above the average length and were very well prepared. It

may be of interest to compare the results of the chemical examination in the present instance with the figures obtained for specimens of Burmese and Calcutta Sann hemp previously examined at the Imperial Institute :

| | No. 3 from [illegible] | No. 2 from [illegible] | No. 1 from Kaliora. | Burmese Sann Hemp. | Calcutta Sann Hemp. |
|---|---|---|---|---|---|
| | Per cent. | Per cent. | Per cent. | Per cent. | Per cent. |
| Moisture | 8·0 | 8·3 | 8·2 | 9·8 | ·4 |
| Ash | 0·3 | 0·3 | 0·3 | 3·1 | 0·6 |
| a. Hydrolysis loss | 7·5 | 6·3 | 6·7 | 9·2 | 10·5 |
| b. Ditto ditto | 16·0 | 15·7 | 15·7 | 15·8 | 14·0 |
| Acid purification loss | 1·0 | 1·0 | 1·1 | 3·7 | 1·6 |
| Cellulose | 87·9 | 88·8 | 87·6 | 87·5 | 90·8 |

This comparison indicates that the three samples from Eastern Bengal and Assam were of very good quality, and closely resembled those received from Burma and Calcutta. The results of this investigation show that the Sann hemp of the Pabna District is of a quality which would find a ready sale at good prices in the United Kingdom. The cultivation of this crop, say the authorities of the Imperial Institute, can therefore be safely extended.

(2) *Calotropis Gigantea* is a shrub that grows all over India and is found at heights up to 3,000 feet. Its olive green velvety leaves and lavender coloured blossom are familiar in the jungles, and occasionally in gardens, and the silky white fibre that fills its seed pods has been the subject of many an unsuccessful attempt at spinning. In times of unusual drought, when half of the jungle trees seem to be dead, the *Calotropis* seems quite unaffected, showing it to be an exceedingly hardy plant. Like the flax plant it possesses a valuable fibre that lies between the woody stem and the bark. This fibre is utilised by villagers for the manufacture of very strong ropes, and by fishermen on the Indus for their lines and nets; but the work of extraction is laborious and slow on account of the branching character of the plant, which seems to have an isolated habit. This is probably the reason why no machine has been found to be capable of extracting the fibre. *Calotropis* or *Akh*, to use the vernacular

name, does not appear to have been cultivated anywhere for its fibre, but a recent experiment of Monsieur Faure, whose name is permanently associated with the utilisation of ramie, seems to open up a good prospect for *Calotropis*. M. Faure, whose decorticating machine is still the best in the market, has made a long study of the cultivation of ramie, both in France and among the planters in India. In the latter country, it is planted like tea in spaces 4 by 4 feet apart with ample room for lateral growth, and the production of branches. M. Faure, on the contrary, has planted his cuttings at 13 inches distance, so that one acre contains 3,600 roots. From a plot of half an acre at Limoges he obtains regularly each year one ton of dry fibre in two crops. This represents two tons per acre, or four times what is obtained by planters in India. M. Faure's machine is best suited to deal with straight stems and his system of close planting produces just such stems as he requires, in great profusion, and the loss of fibre during treatment is reduced to a minimum. It is, therefore, probable that if the *Calotropis* were planted as closely, the growth of lateral branches would be suppressed and long straight stems would take their place. Even without the aid of any machine, straight stems, if they could be produced by close planting, might so facilitate the decortication by hand labour as to show a profit to the ryot. An experiment may be so easily made that a small plot might settle in one season the question whether the *Akh* is subject to the same influences as ramie. (*Indian Textile Journal*, November 1910.)

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SILK-WORM REARING IN THE PUNJAB.—The Punjab Department of Agriculture's Bulletin, No. 3 of 1910, consists of a series of interesting notes on the methods of silk-worm rearing adopted in the Province. The notes have been written almost entirely from materials collected by Mr. Milne, Economic Botanist, Punjab, and are based on M. L'Arboussett's book on "Silk and the Silk-worm" and on experience gained during two years' rearing at Lyallpur and Gurdaspur. As these notes have special reference to local conditions, they ought to fulfil the object for which they have been published, *viz.*, to afford useful guidance to officers whose duty it is to control sericultural operations.

Part I of the Bulletin gives much useful information on the cultivation and care of mulberry trees. It points out that all the local varieties of mulberry are suitable for rearing silk-worms in the Punjab and that the Philippine mulberry (*Morus multicaulis*) is specially useful for producing leaf early in the season. It has been found that the mulberry can be propagated either from seed, from layerings or from cuttings, and instructions are given for propagation in each of these ways. Layering, however, has been found troublesome, and on the whole propagation by cuttings seems to be the simplest and most efficacious method. A useful section is that dealing with the pruning of mulberry trees, and that on the rejuvenation of old trees. Special emphasis is laid on the facts that pruning should be done with a sharp knife, rather than with scissors, and that large wounds should be coated with tar to prevent disease germs entering.

Part II deals with the care of silk-worms. It points out that the first essential to success is to secure eggs free from disease and notes that previous failures in silk-rearing in the Punjab and Kashmir were largely due to the use of diseased eggs. Reliable French eggs can now be obtained from the Director of Agriculture, Punjab, if notice is given before May 15th, the eggs costing about Rs. 2-8-0 per ounce. It is pointed out that one ounce of eggs requires about 25 well-grown mulberry trees and that one ounce of eggs is the quantity that can be conveniently managed by one family. Imported French eggs have to arrive in India early in October, and it has been found from experience in the Punjab that they must, on arrival, be kept in cold storage or sent to the hills. The temperature of storage must not rise above 50 F., and if they are kept at this temperature for 15 days incubation starts, and, when once started, cannot be stopped. This part of the Bulletin lays special emphasis on the necessity for having temperatures accurately recorded, on having the incubating room thoroughly disinfected, and on the necessity of starting incubation at the proper time. To start incubation the temperature of the room should be raised to 60° F., as soon as the mulberry trees begin to show buds. This is about February 12th in the Central Punjab. When incubation has started, the temperature should then be increased one degree each day until it is above 77°. The worms will hatch out in about 14 days from the starting of incubation and the temperature of 77° is a suitable one to maintain them at until the first moult. After this, 74° F. is required and anything above 80° F. has been found to be injurious. The Bulletin recommends that if sericulture is established in the Punjab, a cheap and simple French incubator—the "castelet," will be found very convenient.

Important instructions are given on the space which should be allowed for the worms from one ounce of eggs. The following table gives the results of experience on this point :—

| | |
|---|---|
| Birth to first moult ... ... | 50 sq. ft. |
| First to second moult ... ... ... | 80 „ |
| Third to fourth moult ... ... ... | 120 „ |
| Fourth to rising ... ... ... | 300 to 500 „ |

Emphasis is laid on the fact that native rearers invariably overcrowd their worms.

The quality and quantity of food given to silk-worms at their various stages has an important effect on the quantity and quality of the silk produced and the Bulletin points out that a common fault among native rearers is an insufficient supply of food to meet the voracious appetite which the worms develop after the fourth moult and before rising. Attention is drawn to the fact that sudden changes in the food supply ought to be avoided, while dusty, wet, fermented, or dried up leaves, should never be supplied. Fermented leaves are held to be the cause of the disease known as "flacherie." It is recommended that worms should be fed five times a day at about intervals of four hours each.

A description is given of the various kinds of faulty cocoons, with the causes of their production and an account is given of the commoner diseases of the silk-worm with symptoms and known remedies or means of prevention.

That the outturn of silk can be much increased by careful attention to the points on which the Bulletin lays emphasis is demonstrated by the results of experiments conducted at Gurdaspur, Changa Manga, and Lyallpur in 1909, quoted in the last paragraph of the Bulletin and given below :

| Name of place. | Ounces of seed. | | Weight of | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Issued. | Hatched. | Green cocoons. | | Dry cocoons. | | Silk. | | [illegible] | | Silk per ounce of eggs hatched. | |
| | | | M. | S. | M. | S. | S. | C. | S. | C. | S. | C. |
| Gurdaspur | 23 | 18 | | | 4 | 1 | 31 | 13 | 15 | 2 | 1 | 14 |
| Changa Manga | 2 | 2 | 2 | 36 | 0 | 29 | 7 | 2 | 1 | 15 | 3 | 9 |
| Lyallpur | 1 | [illegible] | 1 | 8 | [illegible] | 15½ | 3 | 2 | 1 | 1½ | 3 | 2 |

The fact that the weight of silk per ounce hatched was much higher at Lyallpur and Changa Manga than at Gurdaspur is due to the worms at the latter place having been entirely in the hands of native rearers using faulty methods, whereas at the two former places they received careful treatment in accordance with the principles laid down in the Bulletin. (A. McKERRAL.)

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A FEEDING MEAL FROM THE SCUM OBTAINED IN GUL BOILING. In a recent leaflet issued by the Bombay Department of Agriculture, attention is drawn to the fact that in the process of *gul* boiling, as practised in the indigenous way, considerable loss results from inability to utilize the scum which forms on the surface of the pan. The scum amounts to about forty pounds for every one thousand lbs. of juice handled and the Department, in a former leaflet, showed that half of this loss might be saved by the use of a scum strainer. The present leaflet describes a process whereby the remaining twenty pounds, instead of being thrown away as it is at present, may be converted into a valuable cattle food. The process, together with information on the proper methods of feeding cattle with the product, is given as follows :—

Mix an equal quantity of water with the strained scum, and bring the resulting liquid to the boil in a *gul* pan. Any old rejected pan will do for the purpose. As soon as it boils, fine powdery *megass* should be mixed with it in the proportion of one part of *megass* to four of the original scum. The fire is then immediately stopped, and the whole mass is stirred until it is fairly cool. Then it is spread out on hard ground in the sun until thoroughly dry.

The fodder produced in this way is a very rich food, easily digested. It can be fed to cattle, at the rate of eight pounds per head per day—four pounds in the morning and four pounds in the evening. The *scum-meal* so prepared from the refuse of one *gul* boiling furnace is quite enough for all the bullocks required to work the mill supplying that furnace, and for them will entirely replace the safflower or other cake now given. Where *gul* making is carried on on a larger scale with a power-mill, it has been calculated that the cost of the *scum-meal* is about twelve annas per one thousand pounds of the product. It can then be fed to farm cattle or can be sold. Even if its price, for sale, be taken at so low a figure as one hundred pounds per rupee, it means a return of Rs. 10 per acre, costing about twelve annas only to make.

There is no difficulty in feeding it to cattle, provided the meal is quite dry. It should not, however, be left over till the monsoon, as it then becomes moist, and the cattle do not eat it readily. It should not be fed to cattle in larger quantities than four to five pounds per head at one time. (A. McKERRAL.)

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SUGAR INDUSTRY IN THE ISLAND OF NEGROS.—We have received a copy of Mr. H. S. Walker's account of the sugar industry in the Island of Negros.

Negros is one of the smaller of the Philippine group and has an area of some 2,000 sq. miles and produces some 1[illegible],000 tons of sugar annually, which is nearly all exported. It is thus among the smallest of the producing centres.

The cane is grown principally in coast lands, the soils being largely of volcanic origin. Nearly all the cane is a purple variety. It is reproduced either from tops only or from cuttings of the whole cane; it is cut after 9 to 14 months' growth. The juice contains from 15 to 18 or 19 % of sucrose; quotient of purity is about 85 to 90 %; it is therefore of good quality. It is generally free from disease, but suffers from insect pests to a certain extent. The outturn of sugar varies a good deal, namely, from half a ton to as much as 5 tons per acre, and averages about one ton. Manures are but little used and the cultivation is indifferent. Considerable labour difficulties are met with.

Regarding manufacture, the cane is pressed in either steam driven iron mills of British manufacture, or in mills, driven by water power or cattle power; of these the first named greatly predominate. The juice is boiled down to a solid raw-sugar, which presumably resembles Indian "gur," in a series of flat-bottomed open pans, the process being apparently very similar to that commonly employed by the sugar boilers of the Western Districts of the United Provinces. (J. W. LEATHER.)

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AN IMPROVED METHOD OF SOWING MAIZE.—Maize is a very important crop in the western part of the United Provinces. It is sown, as a rule, when the rains break, but a certain amount is put in May and early June after the ground has been irrigated. The seed is sown either broad-cast or is dropped into the furrows behind the plough, *i.e.*, in rows 10" to 12" apart. Later on the crop is weeded and the maize plants cut out where they are very thick together. The crop grows luxuriantly on good soil and attains a considerable height.

Having some slight knowledge of the methods of maize cultivation in America it occurred to me that the cultivators of this circle were growing their crop much too thick to get the best results. To test this, experiments were made on the farm at Aligarh in 1909. One series of plots was sown in the ordinary way. In the second series the seed was sown in lines 2′ apart and later on the plants were thinned out to about 1′ apart in the rows. At harvest time, the second series yielded 40% more outturn than the first. This meant an increase of about Rs. 12 per acre.

These results were brought to the notice of Zemindars and cultivators and many expressed their willingness to try the new method of sowing. Returns now to hand from the districts of Etah, Aligarh, Meerut and Saharanpur indicate that the method has been very successful. It is hoped it will spread considerably this year. If, in addition to sowing in lines, we can induce cultivators to do regular intercultivation, a still greater increase in produce will result. (A. E. PARR.)

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DAIRY COW TESTS IN CONNECTION WITH AGRICULTURAL SHOWS. In some of the shows where prizes are given to the best milking cows, the practice is to bring the cows to the show grounds on the evening previous to the show where they are milked that evening as well as again on the following morning. The milk is afterwards weighed and the sample is tested for percentage of butter fat. This is not a fair test because the cows are not in their usual surroundings and are consequently excited. It has generally been the experience of dairymen that when animals are taken from their home surroundings and milked in a strange place amidst excitement, they do not yield their usual quantity of milk. Good milkers are especially nervous in temperament and such cows are more easily upset in shows and competitions. In order to overcome these difficulties a practice is coming into vogue in parts of Australia by which the cows are milked in their usual surroundings under the supervision of officers of the show or competition both in the morning and evening of a day in the two weeks previous to the Show, and the day's butter production is taken as the basis of deciding the cow's yield. (EDITOR.)

# REVIEWS.

BULLETIN OF THE BUREAU OF ECONOMIC AND SOCIAL INTELLIGENCE OF THE INTERNATIONAL INSTITUTE OF AGRICULTURE, 1ST VOLUME, No. 1, SEPTEMBER 1910.

THE International Institute of Agriculture publishes (1) a monthly Bulletin of Agricultural Statistics, (2) a Bulletin of Agricultural Intelligence and Diseases of Plants, and (3) a monthly Bulletin of Economic and Social Intelligence. The first number of the last of these is represented by the volume now under review.

In the words of the preface the object of these bulletins is "to collect and publish all information bearing upon the working of co-operative societies and other agricultural associations, in order to facilitate their organisation and development and to throw light upon the most pressing problems connected with economic and social matters." In the present volume, the countries dealt with are Germany, Austria, Denmark, the United States of America, Great Britain and Ireland, Italy and Japan. Each country, as being economically and politically independent, is dealt with under five different heads. The first head details the demographic and social conditions of the country in order to show the relations of these to the specific character of its agricultural organisations. Thus, it discusses statistically such matters as territory, and population, occupations of the people, birth and death rate, illiteracy, emigration, division of land areas as arable, vineyards, etc., principal products, classes of landholders, live stock census, fisheries, mines, manufactures, navigation and inland communications, finance, money, and weights and measures. Under the second head are presented short studies of monographs dealing with a part or the whole field of the agricultural organisation of the country. Thus in the present volume, under the head of Germany the first study is an interesting historical and statistical sketch of the present state of agricultural co-operation in that country, which details the life and early labours of Raiffeisen, Schulze and other pioneers in the field of scientific co-operation, with special reference to the Raiffeisen Bank System. The second monograph deals with another characteristic form of co-operation in Germany—Co-operative Land Credit Societies—the "Landschaften" and "Ritterschaften." Similarly for other countries under this head, subjects of the greatest importance in connection with co-operation are dealt with. These monographs are accompanied by statistical tables giving varied information of the highest importance.

The third part deals with such problems and facts as are of immediate importance to the working of the various organisations and will in future give special attention and prominence to any new measures which have been found useful in extending the objects of these. Under this head, in the case of Germany, we find discussed Co-operative Electric Light and Power Societies—an attempt to supply suburbs and rural districts with electric power, and in the case of Italy an account of the organisation of a Central Bank of Co-operation and Labour. The fourth part deals with current up-to-date news of the co-operative movement. It gives account of recent legislation in favour of agricultural organisations, makes reference to the work accomplished by the most successful federations and to the resolutions which they have passed, gives any other items of news of importance and finally presents a bibliographical summary of the latest books dealing with the co-operative movement. The fifth part deals with subjects which, although not bearing directly on agricultural co-operation, are yet of great importance to agriculturists. Such subjects include agricultural legislation, the organisation of markets for chemical manures, seeds, implements, &c., and also the development of non-agricultural co-operative societies. Thus in the present volume, we find under this head such subjects discussed as "The New Law on the Sale of Land in Small Lots in the Kingdom of Bavaria" and "The New Legislation for the Preservation of Peasant Properties in Austria."

The present volume deals with agricultural co-operation only, but in future numbers it is proposed to take up agricultural insurance in all its forms and in due course non-co-operative agricultural credit.

The sources of information used in the publication of the Bulletin are either (1) official, *i.e.*, supplied by governments or under their responsibility; (2) communicated by societies, co-operative or otherwise; and (3) obtained from the publications of all kinds whether official, private, or issued by associations. A complete list of authorities is quoted at the head of each section.

It need scarcely be said that this Bulletin is a piece of work of the highest importance. Compiled from the most reliable sources, it deals with agricultural economics from every point of view historical, statistical and legislative and as a means of comparing the methods of co-operation in vogue in different countries, it will be equally useful to agriculturist and official. The Chief of the Bureau M. G. Lorenzoni in his preface expresses a desire for greater collaboration between the Governments and Societies on the one hand and the staff of the Bureau on the other. It is to be hoped that, considering that the work is of supreme international importance, his wish may be fully realised in the future. (A. McKERRAL.)

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PROGRESS IN IRRIGATION BY PUMPING IN MADRAS, BY ALFRED CHATTERTON, DIRECTOR OF INDUSTRIES, MADRAS. (A PAPER CONTRIBUTED TO THE INDUSTRIAL CONFERENCE HELD AT ALLAHABAD IN DECEMBER 1910.)

THE object of this paper is "to put on record what has actually been done and to suggest the directions in which progress on the engineering side of the question is likely to facilitate extensions." It is stated that a regular attempt to use oil engines for pumping water dates in the Madras Presidency from 1902 when there was only one oil engine installation worked by Government. Rapid progress has since been made in this direction. There are at present more than 250 pumping plants erected both by Government and private individuals. Up to this time oil engines working with liquid fuel, which is the residue left after the distillation of the crude petroleum, were employed. But recently suction gas plants and gas engines working with charcoal are being introduced. The introduction of steam engines does not seem possible as the price of coal is prohibitive.

It is calculated that these pumps irrigate about 12,000 acres of land. It is difficult to arrive at the actual cost of irrigation as it depends upon a large number of factors which vary with almost every installation. It is, however, roughly estimated at Rs. 30 per acre per annum.

Mr. Chatterton takes notice of a gas pump newly invented by Mr. H. A. Humphrey. The chief advantage of this machine is that the inventor has successfully combined both engine and pump and has practically eliminated the moving parts, thereby saving the expenditure on wear and tear and lubrication. The construction of this machine is very simple and Mr. Chatterton hopes that it will come into general use in India.

It is reported that some improvements have also been made in the old methods of lifting water by modifying the construction of the common lift pump so as to permit it to be worked with a loose fitting tubular piston. It can be worked either by manual power or by a small power engine. By manual labour it can raise from 500 to 2,000 gallons of water per hour. It is most suitable for the locality where the supply of water is small. Mr. Chatterton suggests the employment of a common engine to drive a number of such pumps situated within a reasonable distance which can be connected by a wire rope. The method suggested is similar to the one employed in the oil fields of California.

The use of mechanical methods of pumping water has led to a considerable increase in the number of wells in the Madras

Presidency. A large area of land having an abundant supply of water has also been discovered. Considerable work has been done in this direction which is capable of further extension.—(EDITOR.)

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INTERIM REPORT FOR THE FIRST CROP YEAR, 1908-09, OF THE NIRA CANAL TAGAI LOANS SCHEME, POONA DISTRICT.

SUGARCANE is largely grown on the land irrigated by the Nira canal, and its cultivation is very profitable, but on account of the poverty and ignorance of cultivators most of the profits find their way into the pockets of the *sowkars* or money-lenders, who not only charge heavy rates of interest but also compel the cultivators to purchase the manures, such as oil-cakes, etc., and to sell the produce through them, charging them heavy brokerage. The result is that a very poor margin of profit is ordinarily left to the cultivator and in adverse years it is practically nil. With a view to finance the cultivators on much easier terms and to secure them their well-earned profits, the Government of Bombay sanctioned in 1908 a scheme for advancing *tagai* to sugarcane cultivators of the Nira canal. The principal feature of this scheme is that the cultivator financed by Government is asked to bring his produce to the Government shop for sale. This serves a double purpose. It secures the payment of the loan made by Government and saves the cultivator the heavy brokerage and other charges levied by local merchants. Arrangements are also made for distributing oil-cakes to cultivators at fair rates. The report before us shows that the scheme has been found to work with success. Loans are given on a long-term basis or short term basis. Long-term loans are given to enable the cultivator to commence and complete his operations from ploughing to harvesting and is repayable within 16 months, whereas short term loans are usually given for the purchase of manure and for crushing operations, and are repayable within 12 months. Nearly 300 cultivators took advantage of the scheme and got net profits, ranging from Rs. 50 to Rs. 300 per acre, the average net profit being Rs. 140 per acre. This compares favourably with the profits on this crop reaped in other parts of India, which vary from Rs. 18-8-0 per acre in the Punjab, to Rs. 118 in Lower Bengal.

The scheme is thus likely to improve the material condition of cultivators in these parts in course of a few years. Several instances are quoted in the report which show that some of the cultivators financed by Government have made sufficient profit to defray the expenses and to liquidate their old debts.

The question of finding a suitable agency to take over from Government the work which is being carried on under the scheme is engaging the attention of the Government of Bombay. Pending a decision on this point the present operations will be continued. -(EDITOR.)

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IMPROVEMENTS IN AGRICULTURE IN SOUTHERN INDIA (A PAPER READ AT THE INDUSTRIAL CONFERENCE, 1908, MADRAS). BY MR. M. R. RAMKRISHNA IYER, HIGH COURT VAKIL AND SECRETARY, DISTRICT AGRICULTURAL ASSOCIATION, TINNEVELLY.

THE subject of this paper is to show how improvements can be effected in the agricultural industry of India in general and Southern India in particular. After a short introduction in which it is pointed out how the farmers in the United States of America and other advanced countries of Europe are making large profits by the application of science to agriculture, the author describes in detail what improvements are possible in this country in the various lines of operations from preparation of the land to harvesting the crop. He observes that in some parts of this country the agricultural practices are so good that it is difficult to suggest an improvement, but at the same time he holds it as a fact that owing to the want of knowledge on the part of the ryot of the principles of agriculture, the agricultural practices have remained almost stationary during the last thirty years, and that considerable improvement is possible by adopting methods of proved value. The following are most of the salient points of improved farming suggested by the author as applicable to the circumstances of this country. They are in substance such as have been tested on Government farms and are being recommended by the Department.

The land should be ploughed deeply by an improved iron plough which stirs the soil to a great depth, which is an advantage over a country plough. To give a fine tilth a grubber or cultivator or a country plough can be used. Though deep ploughing is not often needed, stirring of the soil to some depth is necessary, to enable it to receive a large portion of rainfall, a thing absolutely necessary especially in dry areas. It is desirable to enclose lands with fences as far as possible, but what is more needed is that all the lands including dry lands should be divided into plots and bunded with small embankments to allow the rain water to sink into the soil, and to minimise the risks of the soil fertilisers being carried away by the first rains. The land should be frequently harrowed to produce a soil mulch to avoid evaporation of moisture from the soil. The author recommends for this operation the country "Guntaka," of the ceded districts or the new harrow designed by Mr. Sampson, Deputy Director of Agriculture, Madras. The application of humus or vegetable matter especially to dry lands is emphasised. For this purpose not only leguminous crops should be raised on the land itself, but to provide leaf manure legumes like *kolinji* (*Tephrosia purpurea*) and *avarai* (*Cassia auriculata*) ought to be grown on all waste uncultarable lands. Considerable stress is laid upon the value of conserving cattle manure, solid and liquid, which is at present wasted in burning or otherwise. For concentrated manures when needed, oil-cakes and bones in the form of bone meal are recommended. Sowing should be done in drills as this facilitates interculture, which is necessary not only to aerate the soil but also to conserve moisture. In transplanted paddy, transplantation with single seedlings is more profitable than that with a bunch of 10 or 12 which is to some extent common in Southern India. The value of using selected seed, observing rotation and growing variety of crops is fully explained. Finally the author looks to Government for help by opening seed farms for distribution of selected seed, by investigations and experiments in various agricultural stations to find out improved methods, by disseminating results of proved value through publications, demonstrations and agricultural associations and by spreading agricultural education among rural classes.—(EDITOR.)

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### BULLETIN ON ENTOMOLOGICAL RESEARCH.

THIS bulletin is issued by the Entomological Research Committee (Tropical Africa) appointed by the Colonial office and deals with the insects of Africa which injure men or domestic animals by conveying or causing disease, or which attack economically valuable plants. Three numbers have been issued, dated April, July, October, 1910 ; each consists of about 80 pages with about five plates, and the paper, print and plates are excellent. The subscription is small, ten shillings for the first year.

The bulletin is of interest to entomologists in all parts of the world as well as to residents in Africa ; it is not meant to be popular but is a record of scientific work.

The first number commences with a paper on "The Pupal Stages of West African Culicidae" with seven plates ; a paper on the blood sucking diptera met with in the Eastern and South Eastern Abyssinia follows, and then "Notes on two West African Hemiptera injurious to Cocoa." New coccids and fruit flies from Africa are described, a new *Cordylobia*, and the number closes with a note on parasites of wild silk worms and a list of collections received.

The second number opens with an account of the fleas found on three species of *Mus* ; the bionomics of two species of Tabanus follows, then a survey of the more important families of *A*[illegible], an account of a mealy bug injurious to the Lebbek trees of Cairo and notes on the habits of *Glossina fusca*.

The third number opens with an article on West African fruit-flies by the Director of the Medical Research Institute, Lagos, the habits of *Glossina morsitans* are described, and an account is given of the investigation into the origin of sleeping sickness infection in the Luangwa valley ; and the movements of *Glossina morsitans* are described as well as the scale insects of

Uganda; there are comments by Mr. Green of Ceylon on the earlier paper on Uganda *Coccida* and a precis of reports submitted by district residents concerning Tsetse fly and cattle disease in the Nyasaland Protectorate. Notes on various topics conclude the number.

The publication may fill a useful purpose in affording a medium for papers on *Glossina* and other biting flies, and it may be hoped it will ultimately confine itself to one line. It must either become purely economic, medical or faunistic of Africa; no publication can successfully cover the whole ground. To medical men interested in biting flies the bulletin will be of value and it should find a place in some of the libraries in this country. The three numbers are rather mixed, but it may be hoped that the bulletin will eventually find its line and fill a want. Entomological literature grows so fast that it is hard to keep track of it all, but it is not difficult to follow a publication that has a line of its own and keeps to it, which this bulletin should eventually do.—(H. M. Lefroy.)

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A Monograph of the Culicidæ or Mosquitoes. By Fred. V. Theobald. Vol. V, pp. xv + 646 + 6 plates. London, 1910; *British Museum* (Nat. History). Price £1-5-0.

When Mr. Chamberlain sent out his circular from Downing Street in 1898 requesting all Colonial authorities "to be good enough to take the necessary steps at your early convenience to have collections made of the winged insects . . . . which bite men or animals," we doubt whether even Entomologists foresaw the great importance of the issues involved or the vast number of new forms which awaited investigation. At that time the species recorded from India totalled four only. In 1900 Colonel Giles was able to record 32 species and stated in the Journal of the Bombay Natural History Society (Vol. XIII, p. 603) that he had "little doubt the final total of species will be found not far off a hundred." This estimate can only be described as a modest one; we know no less than 168 different species or varieties sufficiently distinct to be accounted worthy of a name and which occur within the limits of

India, Burma, and Ceylon. Nor have we any grounds for considering that this number is more than a fraction of the forms actually present. In spite of the good work done by many investigators in India during the last decade, our knowledge of Indian Mosquitoes from a systematic point of view is still very scrappy and incomplete and the constant stream of new discoveries is the best proof of the many other facts awaiting to be discovered. All of us who live in India are only too painfully familiar with the appalling loss of life and health caused annually by malaria and other mosquito-borne diseases. At the present stage of our fight against this loss it is important to have at our command every item of information that we can gather about mosquitoes in India, and every resident in India can help in this. In the preface to the volume under review we read :—"The localities from which new collections are specially desired by the Museum are . . . . East Indies." We can all help by collecting mosquitoes and sending them in to the British Museum with notes on their occurrence, *e.g.*, where found, whether in bungalows or in jungle, at what time of year, whether they bite and, if so, at what time of day, where they breed, what preys on them, etc. Mosquitoes are ubiquitous in India; like the poor, they are always with us, in the hills or plains, in the hot weather, the rains or the winter, and accurate notes on the distribution and habits of even the commonest species will be welcome.

It is greatly to be regretted that the classification of the Culicidæ should have been carried out hitherto on characters of so trivial a nature as have been employed. In his introduction the author tells us that "the system of classification by scale-structure apparently works out well from a practical point of view." From the point of view of the ordinary non-entomological inquirer who only wishes to be able to name his specimens, we admit that the use of a purely artificial system of keys based on scale-structure is as good as any other, but we cannot concede that the scheme can be considered sound from a strictly scientific standpoint. Such a multiplication of genera based on trivial characters could only produce a state of chaos were it applied to the classification of any other group of insects. We doubt also the true affinities of some of the species thus artificially brought together and would instance the two species given on page 227 under the genus *Pseudohowardina*, one of which occurs in North America, the other in Ceylon, two faunal regions which otherwise have practically nothing in common.

The present volume is especially valuable as containing a general résumé of our knowledge of the Mosquitoes of the world, the new species or those described since the publication of Volume IV being described at length and the others briefly noted, references to literature and localities being recorded under each. The book is thus a catalogue of practically all the species known, grouped in the systematic order considered most natural by the author after his long study of this family.

We note by the way, that the author states in his Introduction that he "has only been able to devote his leisure hours" to this study. Surely it would repay us as a nation to devote a little more serious attention to the study of insects which generally pay only too much attention to us!

We cannot congratulate Mr. Theobald on a happy selection of some of his generic and specific names. *Culiciomyia*, *lopho-centralis*, etc., are barbarous hybrids between Greek and Latin, whilst names like *freetownensis*, *annuloabdominalis*, *leptosomatomyia*, whilst unnecessarily long and cumbrous, do not seem to possess the redeeming merit of pointing out any special character which may assist the student in recognising the species concerned.

There are, on the whole, few misprints, but Eastern localities, as usual in books of this character, often get transformed into strange shapes; thus, Pundaluoya becomes Pundabroya (p. 221, l. 7), Bhim Tal becomes Brim Tal (p. 159, l. 15), etc.

We notice one error of reduplication. *Trichorhynchus fuscus*, Th., from Peradeniya, figuring in two places, on page 262 and again on page 269. (T. BAINBRIGGE FLETCHER.)

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# LIST OF AGRICULTURAL PUBLICATIONS IN INDIA FROM THE 1st AUGUST 1910 TO THE 31st JANUARY 1911.

| No. | Title. | Author. | Where Published. |
|---|---|---|---|
| | | *General Agriculture.* | |
| 1 | The Agricultural Journal of India, Vol. V, Part IV, and Vol. VI, Part I. Price, per part, Rs. 2-0. Annual subscription, Rs 6. | Agricultural Research Institute and College, Pusa, Bengal. | Messrs Thacker, Spink and Co., Calcutta. |
| 2 | Area & Yield of Certain Principal Crops in India for various periods, from 1895-96 to 1909-10. Price, 4 annas. | Commercial Intelligence Department of the Government of India. | Government Printing India, Calcutta. |
| 3 | Prices and Wages in India. Price, 2 rupees. | Compiled in the Office of the Director-General of Commercial Intelligence. | Ditto. |
| 4 | Indigo Reports .. | Rawson and Bergtheil | Baptist Mission Press Calcutta. |
| 5 | Report of the Indigo Research Station, Sirseah, for 1909-10. | C. J. Bergtheil | Ditto. |
| 6 | Sixth Report of the Sirseah Sub-Committee to the Directors of the Behar Planters' Association, for the year ending 31st March 1910. | Behar Planters Association, Muzaffarpore. | Ditto. |
| 7 | *Oryza Sativa.*—Literature on the Races of Rice in India. Agricultural Ledger No. 1 of 1910. First half, A-K. Price, 12 annas. | Compiled in the Office of the Reporter on Economic Products to the Government of India. | Government Printing India, Calcutta |
| 8 | Guano and Edible Frogs. Agricultural Ledger Nos. 1 and 2 of 1911. Price, 1 anna. | I. H. Burkill, M.A. | Ditto. |
| 9 | Agricultural Statistics of India for the years 1904-05 to 1908-09, Vol. I. Price, Rs. 2. | Compiled in the Office of the Director General of Commercial Intelligence | Ditto. |
| 10 | Memorandum on Indian Wheat for the British Market. Bulletin No. 20 of the Agricultural Research Institute, Pusa. Price, 4 annas. | Sir James Wilson, K.C.S.I. | Ditto. |
| 11 | Report of the Agricultural Research Institute and College, Pusa (including Report of the Imperial Cotton Specialist), for 1909-10. Price, 4 annas. | Inspector General of Agriculture in India. | Ditto. |
| 12 | Memorandum regarding Leading Eucalypts suitable for India. Bulletin No. 21 of the Agricultural Research Institute, Pusa. Price, 4 annas. | F. Booth Tucker | Ditto. |
| 13 | Report on the Progress of Agriculture in India for 1909-10. Price, 6 annas. | B. Coventry, Officiating Inspector-General of Agriculture in India. | Ditto. |
| 14 | Quarterly Journal of the Department of Agriculture, Bengal, Vol. IV, No 1 (July 1910), and No. 2 (October 1910). Price, 6 annas per copy. | Department of Agriculture, Bengal. | Bengal Secretariat Press Calcutta. |

## LIST OF AGRICULTURAL PUBLICATIONS—*contd.*

| No. | Title. | Author. | Where Published. |
|---|---|---|---|
| | *General Agriculture—contd.* | | |
| 15 | Annual Report of the Department of Agriculture, Bengal, for the year ending 30th June 1910. Price, 8 annas. | Department of Agriculture, Bengal. | Bengal Secretariat Book Depot, Calcutta. |
| 16 | Notes on Agricultural Shows with Recommendations for Future Exhibitions. Departmental Record No. 1 of 1909. (Not for sale.) | E. J. Woodhouse, B.A. | Bengal Secretariat Press, Calcutta. |
| 17 | Annual Report of the Agricultural Stations in charge of the Deputy Director of Agriculture, Bengal, for the year 1909-10. Price, 4 as. | F. Smith, B.Sc., F.H.A.S. | Bengal Secretariat Book Depot, Calcutta. |
| 18 | Annual Report of the Kalimpong Demonstration Farm for the year 1909-10. Price, 8 annas. | P. W. Goodwin. | Ditto. |
| 19 | Some Suggestions as to the Organization of Agricultural Exhibitions in Bengal. Departmental Record No. 1 of 1910. (Not for sale.) | E. J. Woodhouse, B.A. | Bengal Secretariat Press, Calcutta. |
| 20 | Report on the Administration of the Department of Agriculture, United Provinces of Agra & Oudh for the year ending 30th June 1910. Price, 8 annas. | Department of Agriculture, United Provinces of Agra & Oudh. | Government Press, United Provinces, Allahabad. |
| 21 | Annual Report on Aligarh Agricultural Station, for the year ending 30th June 1910. Price, 8 annas. | Ditto ... | Ditto. |
| 22 | Annual Report on the Partabgarh Agricultural Station for the year ending 30th June 1910. Price, 8 annas. | Ditto | Ditto. |
| 23 | Notes on Improvement of Cattle in the United Provinces. Price, 6 pies. Bulletin No. 25 of 1909 of the United Provinces Department of Agriculture. | W. H. Moreland, B.A., LL.B., C.I.E., I.C.S., and E. W. Oliver, M.R.C.V.S., [illegible] | Ditto. |
| 24 | Report on the Operations of the Department of Agriculture, Punjab, for the year ending 30th June 1910. Price, 3 annas. | Department of Agriculture, Punjab. | Civil & Military Gazette Press, Lahore. |
| 25 | Annual Report of the Lyallpur Agricultural Station, for 1909-10. Price, 13 annas and 6 pies. | Ditto | Ditto. |
| 26 | Annual Report of the Department of Agriculture, Bombay, for 1909-10. Price, 8 annas. | Department of Agriculture, Bombay. | Government Central Press, Bombay. |
| 27 | Season and Crop Report of the Bombay Presidency for 1909-10. Price, 7 annas. | Ditto | Ditto. |
| 28 | Annual Report on the Experimental Work of the Surat Agricultural Station for the year 1909-10. Price, 11 annas. | Ditto | Ditto. |
| 29 | Annual Report on the Experimental Work of the Dharwar Agricultural Station, for the year 1909-10. Price, 14 annas. | Ditto | Ditto. |
| 30 | Annual Report on the Experimental Work of the Dhulia Agricultural Station, for the year 1909-10. Price, 10 annas. | Ditto | Ditto. |
| 31 | Annual Report on the Experimental Work of the Nadiad Agricultural Station, for the year 1909-10. Price, 10 annas. | Ditto | Ditto. |

LIST OF AGRICULTURAL PUBLICATIONS—*contd.*

| No. | Title. | Author. | Where Published. |
|---|---|---|---|
| | *General Agriculture*—contd. | | |
| 32 | Annual Report on the Experimental Work of the Dohad Agricultural Station, for the year 1909-10. Price, 10 annas. | Department of Agriculture, Bombay. | Government Central Press, Bombay. |
| 33 | Annual Report on the Experimental Work of the Gokak Canal Agricultural Station, for 1909-10. Price, 8 annas. | Ditto ... | Ditto. |
| 34 | Annual Report on the Experimental Work of the Mirpurkhas Agricultural Station, for the year 1909-10. Price, 7 annas. | Ditto ... | Ditto. |
| 35 | Annual Report on the Experimental Work of the Daulatpur Reclamation Station, for the year 1909-10. Price, 10 annas. | Ditto | Ditto. |
| 36 | Annual Report on the Experimental Work of the Manjri Agricultural Station, for the year 1909-10. Price, 4 annas. | Ditto | Ditto. |
| 37 | Annual Report on the Experimental Work of the Lonavla Agricultural Station, for the year 1909-10. Price, 4 annas. | Ditto | Ditto. |
| 38 | Annual Report on the Kirkee Civil Dairy, for 1909-10. Price, 4 annas. | Ditto | Ditto. |
| 39 | Annual Report on the Work of the Agricultural College Station, for 1909-10. Price, 8 annas. | Ditto .. | Ditto. |
| 40 | Annual Report on the Experimental Work of the Ganesh Khind Botanical Station, for 1909-10. Price, 5 annas. | Ditto ... | Ditto. |
| 41 | Annual Report on the Experimental Work of the Bassein Botanical and Agricultural Station, for 1909-10. Price, 4 annas. | Ditto ... | Ditto. |
| 42 | An Examination of the Seed Supply of the Broach District. Bulletin No. 37 of 1910. Price, 4 annas. | G. D. Mehta, L.Ag., B.A., N.D.A., N.D.D. | Ditto. |
| 43 | Experiments with the Water Finder of Messrs. Mansfield & Co., in the Trap Area of Western India. Bulletin No. 38 of 1910. Price, 5 annas. | H. K. Mehta, M.A., B.Sc. | Ditto. |
| 44 | A Feeding Meal from the Scum obtained in *Gul* Boiling. Leaflet No. 5 of 1910. | Department of Agriculture, Bombay. | Ditto. |
| 45 | Guinea-worm. Leaflet No. 6 of 1910. | Ditto | Ditto. |
| 46 | Report on the Operations of the Agricultural and Civil Veterinary Departments, Madras, for the official year 1909-10. Price, 6 annas. | Department of Agriculture, Madras. | Government Press, Madras. |
| 47 | The Conservation of Cattle Urine. Leaflet in English, Tamil, Telugu and Malayalum. | H. C. Sampson, B.Sc. | Ditto. |
| 48 | Experiences of Single Seedling Planting. Leaflet in English, Tamil and Telugu. | Kolandavelu Udayar .. | Ditto. |
| 49 | Useful facts learnt from the Experimental Cultivation at Taliparamba. Leaflet in Canarese and Malayalum. | H. C. Sampson, B.Sc. .. | Ditto. |

LIST OF AGRICULTURAL PUBLICATIONS—*contd.*

| No. | Title. | Author. | Where Published. |
|---|---|---|---|
| | *General Agriculture*—contd. | | |
| 50 | Useful facts learnt from experimental cultivation at Palur. Leaflet in English and Tamil. | H. C. Sampson, B.Sc. | Government Press, Madras. |
| 51 | Light Traps. Leaflet in English | C. A. Barbar, M.A., F.L.S., D.Sc. | Ditto. |
| 52 | Individual Manuring of Paddy. Leaflet in English and Tamil. | H. C. Sampson, B.Sc. | Ditto. |
| 53 | Practical Lessons drawn from Experiments at the Central Farm, Coimbatore. Leaflet in Tamil, Malayalum, Telugu and Canarese. | R. W. B. C. Wood, B.A. | Ditto. |
| 54 | Useful facts learnt at Koilpatty. Leaflet in Tamil. | H. C. Sampson, B.Sc. | Ditto. |
| 55 | Report on the working of the Department of Agriculture, Central Provinces, for the year 1909-10. Price, 1 rupee. | Department of Agriculture, Central Provinces. | Central Provinces Secretariat Press, Nagpur. |
| 56 | Report on the Agricultural Stations in the Central Provinces and Berar, for the year 1909-10. Price, 1 rupee. | Ditto | Ditto. |
| 57 | Report on the Management of the Provincial and District Gardens, Central Provinces, for the year 1909-10. Price, 8 annas. | Ditto | Ditto. |
| 58 | The Improvement in the quality of Wheat exported from the Central Provinces. Bulletin No. 4. Price, 1 rupee. | G. Evans, B.A. | Ditto. |
| 59 | *Agricultural Gazette*—A monthly publication. Price, 2 annas per copy. | Department of Agriculture, Central Provinces. | Ditto. |
| 60 | Annual Report of the Department of Agriculture, Eastern Bengal and Assam for the year ending 30th June 1910. Price, 8 annas. | Department of Agriculture, Eastern Bengal and Assam. | Government Press, Eastern Bengal and Assam, Shillong. |
| 61 | Annual Report of the Dacca Agricultural Station for the year ending 30th June 1910. Price, 2 annas. | Ditto | Ditto. |
| 62 | Annual Report of the Jorhat Agricultural Station for the year ending 30th June 1910. Price, 2 annas. | Ditto | Ditto. |
| 63 | Annual Report of the Rajshahi Agricultural Station for the year ending 30th June 1910. Price, 2 annas. | Ditto | Ditto. |
| 64 | Annual Report of the Burirhat Agricultural Station for the year ending 30th June 1910. | Ditto | Ditto. |
| 65 | Annual Report of the Shillong Fruit Garden for the year ending 30th June 1910. | Ditto | Ditto. |
| 66 | Annual Report of the Upper Shillong Agricultural Station for the year ending 30th June 1910. Price, 2 annas. | Ditto | Ditto. |
| 67 | Annual Report on the Tropical Plantation at Wahjain for the year ending 30th June 1910. Price, 2 annas. | Ditto | Ditto. |
| 68 | Central Seed Depôt, Dacca. Leaflet No. 2 of 1910. | Ditto | Ditto. |

## LIST OF AGRICULTURAL PUBLICATIONS—*contd.*

| No. | Title. | Author. | Where Published. |
|---|---|---|---|
| | *General Agriculture*—contd. | | |
| 69 | Hints on the Cultivation of the Fig Tree. Leaflet No. 4 of 1910. | Department of Agriculture, Eastern Bengal and Assam. | Government Press, Eastern Bengal and Assam, Shillong. |
| 70 | Report on the Operations of the Department of Agriculture, Burma, for the year ending 30th June 1910. Price, 6 annas. | Department of Agriculture, Burma. | Government Press, Burma, Rangoon. |
| 71 | Scientific Report of the Mandalay Agricultural Station for the year 1909-10. | Ditto | Ditto. |
| 72 | Papers on the Manufacture of Jaggery from the juice of the Toddy-palm with special reference to the effects of the Industry on the Timber Supply of the Dry Zone of Burma. Bulletin No. 3 of 1910. Price, 2 annas. | Ditto | Ditto. |
| 73 | Agricultural Surveys, No. 2 Sagaing District. | Ditto | Ditto. |
| | *Agricultural Chemistry.* | | |
| 74 | The Salt Lands of the Nira Valley. Bulletin No. 39 of 1910 of the Department of Agriculture, Bombay. Price, 5 annas. | Harold H. Mann, D.Sc., & V. A. Tamhane, L. Ag. | Government Central Press, Bombay. |
| 75 | Manufacture of *Gur.* Leaflet No. 5 of 1910 of the Department of Agriculture, Bengal. | C. S. Taylor, B.A. and N. C. Chowdhury. | Bengal Secretariat Press, Calcutta. |
| 76 | Use of Shallow Pan for *Gur* making. Leaflet No. 6 of 1910 of the Department of Agriculture, Bengal. | N. C. Chowdhury | Ditto. |
| 77 | The Composition of Indian Rice. The Agricultural Ledger No. 5 of 1908-09. Price, 4 annas. | David Hooper, F.C.S. | Government Printing, India, Calcutta. |
| | *Mycology.* | | |
| 78 | First Experiments in the Treatment of Grape-vine Mildew in the Bombay Presidency. Bulletin No. 36 of 1910 of the Department of Agriculture, Bombay. Price, 14 annas. | W. Burns, B.Sc. | Government Central Press, Bombay. |
| 79 | The Ring Disease of Potatoes. Bulletin No. 1 of the Mysore Department of Agriculture. | L. C. Coleman, M.A., Ph.D. | Mysore Government Press, Bangalore. |
| 80 | Diseases of Areca Palm, I Koleroga. Price, 2 rupees. | Ditto | Ditto. |
| | *Economic Botany.* | | |
| 81 | Millets of the Genus Setaria in the Bombay Presidency and Sind. Memoirs of the Imperial Department of Agriculture, Botanical Series, Vol. IV, No. 1. Price, 1 rupee. | G. A. Gammie, F.L.S. | Messrs. Thacker, Spink & Co., Calcutta. |
| | *Entomology.* | | |
| 82 | Fasaler Poka. Text-Book. (Bengali). | C. C. Ghosh, B.A. | Indian Gardening Association, 162, Bowbazar Street, Calcutta. |

LIST OF AGRICULTURAL PUBLICATIONS—*concld.*

| No. | Title. | Author. | Where Published. |
|---|---|---|---|
| | *Entomology*—concld. | | |
| 83 | Instructions for rearing Eri-Silk Worms. Leaflet in English, Hindi and Bengali. | H. Maxwell Lefroy, M.A., F.E.S., F.Z.S. | Government Printing, India, Calcutta. |
| 84 | Eri Seed exchange | Ditto | Ditto. |
| 85 | The Rice Hispa. Leaflet No. 1 of 1910 of the Department of Agriculture, Bengal. | H. L. Dutt | Bengal Secretariat Press, Calcutta. |
| 86 | The Rice Fulgorid. Leaflet No. 2 of 1910 of the Department of Agriculture, Bengal. | Ditto | Ditto. |
| 87 | Sugar-cane Borer. Leaflet No. 3 of 1910 of the Department of Agriculture, Bengal. | Ditto | Ditto. |
| 88 | Pests of Pulses. Leaflet No. 4 of 1910 of the Department of Agriculture, Bengal. | Ditto | Ditto. |
| 89 | The Rice Hispa, Cultivator's Leaflet No 24 of 1910 of the Department of Agriculture, Burma. | Department of Agriculture, Burma. | Government Press, Burma, Rangoon. |
| 90 | The Rhinoceros Beetle (*Oryctes Rhinoceros*, Linn) and its ravages in Burma. Bulletin No. 4 of 1910. | Ditto | Ditto. |
| 91 | Practical Hints on Bee-keeping in Simla. Bulletin No 2 of 1910. | Department of Agriculture, Punjab. | Civil and Military Gazette Press, Lahore. |
| 92 | Notes on the Silk-worm rearing in the Punjab. Bulletin No. 3 of 1910. | Ditto | Ditto. |
| 93 | Some Common Insect Pests which attack food-grains. Leaflet No. 3 of 1910 in English, Bengali and Assamese. | Department of Agriculture, Eastern Bengal and Assam. | Government Press, Eastern Bengal and Assam, Shillong. |

# PUBLICATIONS OF THE IMPERIAL DEPARTMENT OF AGRICULTURE IN INDIA.

[TO BE HAD FROM MESSRS. THACKER, SPINK & CO., CALCUTTA.]

Annual Report of the Imperial Department of Agriculture in India for the year 1904-05. Price, As. 12 or 1*s.* 2*d.*

Report of the Imperial Department of Agriculture in India for the years 1905-06 and 1906-07. Price, As. 6 or 7*d.*

Report of the Agricultural Research Institute and College, Pusa, including Report of the Imperial Cotton Specialist for the years 1907-09. Price, As. 4.

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