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CONTENTS.

(Vol. XIV, Part IV.)

ORIGINAL ARTICLES.

SELECTED ARTICLES.

LIST OF ILLUSTRATIONS.

Besides, there is one chart illustrating Mr. Dobbs' paper on "The Frequent Failure of Large Proportion of the Rice Crop in Chota Nagpur."

The following Original Articles will appear in our next issue (October 1919).

VEGETABLES DURING THE MESOPOTAMIAN CAMPAIGN..	G. C. Sherrard, B.A.
SOME FACTORS WHICH INFLUENCE THE YIELD OF PADDY IN COMPARATIVE MANURIAL EXPERIMENTS AT THE MANGANALLUR AGRICULTURAL STATION ..	H. C. Sampson, B.Sc.
THE FRASH (*Tamarix articulata*) ..	W. Robertson Brown.
EXPERIMENTAL ERROR IN VARIETY TESTS WITH RICE ..	F. R. Parnell, B.A.
NOTE ON AN OUTBREAK OF SURRA AT THE GOVERNMENT CATTLE FARM, HISSAR, AND ON CASES TREATED ..	R. Branford, M.R.C.V.S.
NOTE ON LAND DRAINAGE IN THE IRRIGATED TRACTS OF THE BOMBAY DECCAN ..	C. C. Inglis, B.A.I.
IMPROVEMENT OF INDIAN DAIRY CATTLE ..	A. K. Yegna Narayan Iyer, M.A., N.D.D., F.C.S.
THE PREVENTION OF SOIL EROSION ON TEA ESTATES IN SOUTHERN INDIA ..	R. D. Anstead, M.A.
FURTHER EXPERIMENTS AND IMPROVEMENTS IN THE METHOD OF PLANTING SUGARCANE AND FURTHER STUDY OF THE POSITION OF SEED IN THE GROUND WHILE PLANTING ..	M. L. Kulkarni.

LOUIS JAMES KERSHAW, C. S. I., C. I. E., I. C. S. (Retd.).
Secretary to the Government of India,
Revenue and Agriculture Department,
1914-15.

Photo by Fred Bremner,
Simla and Lahore.

Original Articles.

QUO VADIS?

THE PROBLEM OF THE CO-OPERATIVE MOVEMENT IN INDIA.

BY

LIEUT.-COL. H. R. CROSTHWAITE, C.I.E.,

Registrar of Co-operative Societies, Central Provinces and Berar.

"THE frail barque of Co-operation in India"—to borrow the language of the late Sir Harvey Adamson—, was launched and blessed by Government in 1904. Where the little ship would get to nobody quite knew; and there was the usual chorus of birds of ill omen to grate the public ear with a melancholy song. Some said that a co-operative movement was impossible in an Indian environment; others scented danger in the air, thinking that co-operation and socialism were but two names for a single evil. However, the ship set sail, albeit there was no favouring gale of enlightened public opinion behind it. This, of course, was not to be wondered at. The proceedings of the Sixth International Co-operative Congress, held at Budapest in 1904, contain two papers only on Indian co-operation. The one paper is by Mr. Ambika Charan Ukil, "General Secretary of the Co-operative Union of India." "Our Union," reported the General Secretary,—and we may pause to ask what has become of it?—"Our Union has made efforts to collect materials for a statistical account of the progress of co-operation in India. The result is, however, disappointing. In answer to a considerable number of question-sheets sent out to co-operative societies of whom we had heard, we have received only an insignificant number of replies; and those replies give no information except that, in the opinion of the writers, the proportions of their business are still too small to merit mention." The other paper is by Mr. H. E. L. Dupernex, I.C.S., and in it we read that the co-operative movement had made a start and "had been lifted out of the region of academic discussion." This, then, was the manner of the launching of the co-operative movement in India. Government passed an Act, appointed Registrars, and addressed Provincial Governments in a despatch which, compressed into tabloid form, amounted to a command to "get a move on!" Such a procedure recalls to mind not altogether irreverent the first chapter of the first Book of Moses. But with this great difference. When the co-operative movement in India was made to order there was no great architect responsible for its design. Mr. H. W. Wolff was for a time the wise and kindly *deus ex machina* to whom the Government made occasional references. And Mr. Wolff has never worked in India. It was, in fact, left to the provincial Registrars to *dree their own weird*; and so it came about that each province, in the course of a few years, possessed its own particular brand of co-operative brick in the shape of village credit societies of different types.

In 1910, I wrote :—"The great difficulty in co-operative organization is that precedent cannot always solve our problems for us. Co-operative credit must, of course, embrace certain broad principles. But the capable organizer will resemble the skilled *chef*: there may be a sameness about the ingredients; yet the recipes will be different and the results all excellent. Nevertheless, however cunning the artist, however exquisite the art, no *chef* can hope to succeed unless he knows the tastes of the man he has to please. And so with co-operative credit. The particular blend must suit the circumstances of the people and the locality. It is *in the blending* that success or failure is included. Not even a Raiffeisen can hope to organize successful co-operative credit societies without a sound knowledge of the wants (and the limitations) of the locality he is working in. The blind cannot lead the blind; so before the organizer commences operations he must study the conditions and the environment of the village he has to handle. He must become acquainted with the trade, the rates of interest, the customs, the agriculture, and, above

l. the men of the neighbourhood." Every other Registrar was ying, writing, and thinking much the same sort of thing at about iat time. Co-operation, blessed word, was the new medicine of all ills. It was thought that it could be administered in packets ed up with red tape, to be obtained from Registrars whenever eded. Once, when a town had been destroyed by fire, a Registrar as sent for and told to form the homeless inhabitants into co-perative societies and to see that they got money to make a new own with. The cry was all for rules. "We don't want to be othered about the principles. Give us the rules and we will do the est!" That, put generally, was the attitude of the provincial and istrict executives. As for the great non-official world the cry there as all for State aid, for money and for ministerial staff. It was not, owever, a niggardly policy which shut the public purse, but accept-nce of Mr. Wolff's warning that patronage would spoil that co-peration on the purity of which the success of the entire movement nust depend.

Now it is obvious that a "co-operative credit society" which annot find money for its members is unworthy of the name. Where hen was the money to come from? "You will get local deposits," aid Mr. Wolff comfortably. But the Indian peasant, like his rother in other countries, is poor, secretive, and suspicious. The ature of his work tends to make him an individualist to the very narrow, with less disposition than any class to work for the common welfare while working for his own. Varying with the seasons, his ours of labour are often prolonged from sunrise till gloaming and ven far into the night. He is continually haunted by fears for his rops. And in his household the meals taken in common with his amily, the common pursuit, the self-contained home, the blood-bond of kinship, are salient factors which must be taken into account when introducing co-operation in any form to him and his class. The struggling cultivator is actuated little by sentiment; and, if he co-operates, it is solely because he hopes to obtain individual benefit. In introducing co-operation to him, one has to contend not only with the sluggishness of ignorance and the apathy of despair, but with the suspicion of being actuated by a desire to overreach which does not appear on the surface. The Indian peasant who had no money wanted to join a credit society in order to obtain a loan at a rate of interest below that at which the rural moneylender was willing to accommodate him; his richer brother had no use for co-operation; and the village usurer saw ruin and showed fight.

"Needs must when the devil drives." Funds for the credit societies had to be got; and so Registrars, feeling their way cautiously, had recourse to the formation of district or central co-operative banks. I use the word "recourse" because, in truth, there was very little that was co-operative about the first Indian central banks. It was necessary to explain to local capitalists the meaning of co-operative credit, and to show that the societies afforded scope for safe investment with a prospect of a good return. The banks were to make a profit for their shareholders; and the shareholders subscribed *for profit.* "In order to love mankind," said Helvetius, "one must not expect too much from them." Of course, there was a good deal of adverse criticism. In the first place, it was urged that banks of this kind were not the "societies" which the Government of India contemplated when undertaking legislation. Secondly, it was pointed out that they were mere profit-making machines. It was stated that the object of co-operative credit was to obtain reasonable credit from reasonable creditors. Meanwhile, the Government of India, with deep wisdom, stood by and watched —and waited. The fact was that precedent could *not* solve the problems of the Indian co-operative movement in its early stages. Before passing the Co-operative Credit Societies Act of 1904, Lord Curzon appointed a small committee, under the presidency of Sir Edward Law; and the deliberations of that committee may be said to have begun and ended with the primary unit of co-operative organization, namely, the village credit society. The Act of 1904 contained no formal recognition of central societies formed of other societies, nor did it expressly cover any form of co-operation other than co-operative credit. To remedy these and other defects which experience had brought to light, a new Act was passed in 1912 which dealt with co-operation of all kinds.

Between the years 1904 and 1912 the movement in India had iade much progress. The district or central co-operative bank, dmitting village credit societies to membership, had proved its tility. Indeed, without this type of institution the village credit cieties would have got no money, and, as Mr. Wolff has expressed , "what you want in your banks at the outset is, not members', ut *other people's* money." Once the position of central banks had een brought within the four corners of the new Act, the co-operative novement made a great stride forward.

In 1915 there were in India 17,327 societies with 824,000 nembers and a working capital of almost nine crores of rupees. By hat time it had been discovered that the central district banks did ot carry heavy enough guns. They could not command credit utside the limited field of their operations. Moreover, feeder banks f the district type are subject, only in a less degree than the indivi-ual societies they serve, to vicissitudes of season and fluctuations n the demand for money; and, in their turn, they require further gencies from which they can obtain money in the busy months nd through which they can utilize it in the slack season. Some entral banks, thanks to the good offices of Registrars, had obtained oans or cash credits from large joint stock banks. But it goes vithout saying that a co-operative *movement* cannot stand still; novement there must be, either forwards or backwards; and the oint stock banks found the district co-operative banks difficult o deal with. Difficult, that is, not in the sense that they were lack or dishonest, but inconvenient as customers or clients, and his for two reasons. In the first place, the joint stock bank is, as a ule, remote both in methods and in locale from the district co-perative bank. And, secondly, the requirements of credit societies are most difficult to estimate in advance because they depend, n great measure, on good or bad harvests. Thus, a district central bank may be clamouring for financial assistance one moment and, the next, wondering what to do with surplus funds.

It was at this juncture that provincial central banks appeared n the scene as links between joint stock or presidency banks and he district co-operative banks. The advent of the provincial central bank saved weak district banks from perishing for want of funds, and greatly benefited strong district banks, because it provided a convenient clearing house through which surplus deposits or other money could be distributed and retained within the circle of the provincial movement. But it did little or nothing to help Registrars towards a satisfactory solution of the problems of supervision and audit,—problems which in India are extraordinarily difficult because of the intense degree of illiteracy in the villages. It is more than doubtful whether European critics of Indian co-operation grasp the nature of a Registrar's work. Writing in 1910, at a time when there were only 3,498 societies in the whole country, Mr. Wolff pronounced that "the time had indeed come when the movement must, from a quasi-official, be expanded into a national movement if it is to be carried any further." But illiteracy makes any such expansion difficult if not impossible. As Mr. Montagu and Lord Chelmsford have pointed out British India has two and a half times the population of the United States, and 226 out of 244 millions of people lead a rural life. Agriculture is the one great occupation and only 6 per cent. are able to read and write. "What concerns the Indian peasant mainly"—the words are those of Lord Chelmsford and Mr. Montagu, "is the rainfall or the irrigation supply from wells or canals, the price of grain and cloth, the payment of rent to the landlord or revenue to the State, the repayment of advances to the village banker, the observance of religious festivals, the education of their sons, the marriage of their daughters, their health and that of their cattle. They visit the local town on bazaar days and the sub-divisional or business centre rarely on business or litigation. They are not concerned with district boards or municipal boards; many of them know of no executive power above the district officer, and of Parliament or even of the legislative councils they have never heard. In one province it is stated that 93 per cent of the people live and die in the place where they were born." It may be doubted whether this picture, striking as it is, brings out the apathy exhibited by the Indian villager towards education and sanitation. It certainly does not bring out the fact that "local towns" are few and far between. For, a town being defined as a continuous collection of houses permanently inhabited by not less than 5,000 persons," there are only 117 towns in the whole of an Indian province which is as large as England, Scotland, and Wales put together. In the same province the average population of 000 villages is 311 persons only! India is, in fact, a country not of towns but of villages, and, moreover, one in which many new roads, railways, and village schools are very badly wanted if there is to be any comprehensive scheme of rural development.

It has been stated by the Government of India that 3 millions of the people are directly affected and benefited by the co-operative movement; and we may readily agree that "the movement in India is only at its beginning," and that "the progress made in the first stage has been unequalled in any other country." Such agreement, however, ought not to blind us to the fact that there is only one co-operative society in India for every 20,000 of the population engaged in agriculture; and, bearing in mind that Indian villages are, after all, very small places, it may be estimated that there is room for at least 40 credit societies for every 20,000 cultivators, -provided always that the societies can be audited, educated in their work, and financed, and that the margins of economy which they effect for their members (and for future generations of members) are not whittled away by a defective co-operative cycle and an ill-balanced banking system.

The purpose of the co-operative movement is not only to democratize credit but to democratize production as well. Sir Horace Plunkett has more than once declared that if he had his organizing work in Ireland to do over again, it is with banks he would begin, because they are found to pave the way to other forms of co-operation. They supply the means as well as the training. Co-operative banks are, in fact, the great driving wheel of the whole movement. But, at the same time, they form part only of that great engine of co-operation which has contributed so enormously to the progress of modern countries. It is, of course, most important that, at every turn, the savings effected by co-operative economies should be used in such a way as to benefit the individuals from whose joint action they have sprung; in other words, there must be a full cycle of co-operative activity to secure to the producer the full benefits of co-operation. In the absence of such a cycle,—and in 1917, out of 23,000 societies, there were in the whole of India only 1,558 societies for purposes other than agricultural co-operative credit,—much of the energy put into the movement runs to waste; which means that the movement towards better business is retarded and, in many cases, prevented, and that the subsequent stages of better farming or working and better living can never be reached at all. As matters stand at present there is little or no scope for the profitable employment of the reserve funds and surplus deposits held by the movement, while considerations of banking prudence compel the retention, at a loss, of large sums of money in a fluid or liquid state. Frequent tinkering with the rates of interest offered by co-operative banks and societies to depositors has an injurious effect upon public opinion and interferes with the flow of deposit money; and, because the co-operative cycle is incomplete, there is at present no means of passing on the surplus capital of agriculture to fructify, under proper guarantees, in industrial co-operative enterprise. Nor, as yet, is there (*a*) any organization of mortgage credit by means of the bonds which have, in other countries, become an established feature on the stock exchanges and which, because they find a ready market, are a very suitable and convenient form of banking security, or (*b*) any regular facility for the discount of the promissory notes of societies. These grave defects in the scheme of Indian co-operation must be remedied if the movement is to take its proper place as a powerful factor in the economy of the country.

But difficulties of the above kind are not all that the co-operative movement in India has to contend with. The problems of audit and supervision are also acute. If the number of societies increases, then a Registrar is hard put to it to provide audit and supervision; if the number of societies is not allowed to increase, then, unless the flow of deposits be stopped, the movement has to carry surplus funds at a loss. There are obstacles, also, in the way of any practical application of co-operative principles to purposes other than credit. It is, for instance, very often most difficult to get field produce to arket in India because of the prevailing absence of roads. In a ertain tract of wheat country, which is about as large as an average nglish county, the course of trade is as follows. Messrs. - - onduct their purchases through a local agent; the local agent works hrough sub-agents, the sub-agents work through *banias* or *mahajans*; nd the *mahajans*, again, through petty middlemen, each one of whom has a regular beat or group of villages which he plies. These middlemen, or *baiparis* as they are called, conduct their operations with pack-bullocks or ponies. They sell cloth and groceries to their ultivator clients and take payment, when the time comes, in grain r other produce. The *baipari* is the agent; his principal is the *bania* or *mahajan*. And once a cultivator is in the *bania's* books he eldom succeeds in getting out of them. It requires a *comprehensive* rganization to break down a system of this sort,—a system to which he cultivator himself is thoroughly accustomed and which he inds it difficult to see beyond. It is, in fact, impossible for the co-operative organizer to take the cultivator beyond and out of reach of bad economy, until considerable changes have been effected in Indian rural environment by the multiplication of roads, of wheeled vehicles, of farms for the production of pure seed and for the demonstration of improved methods, of facilities for co-operative distribution, supply, storage, and sale, of all these things, and, above all, of schools, so that, in due course, what is now, perforce, a system of audit and control centralized in the hands of a few officials and non-officials belonging to the educated classes may, in the hands of the people themselves, become natural, spontaneous, and decentralized. A great deal of water will have to flow under Indian bridges before that happens; and it never can happen until the problems of rural development are dealt with scientifically and systematically, each as part of a co-ordinated whole, and not by a purely departmental watertight compartmental system. Co-ordinated effort, systematic thinking, a plan of campaign, these are three essentials to any scheme of rural reform, and it matters not a pin to India whether they are provided by Boards of Development, by Development Commissioners, or by Rural Organization Societies, so long only as they are provided. Substantial as the structure of the co-operative movement in India undoubtedly is, the time has come to take stock of the situation. There is a period of development and reconstruction before the British Empire, and an industrial vision is before this great country, a vision which can never come to anything until the co-operative movement with its "better business, better farming, and better living" uplifts the villages of India.

The reader, if he has survived the discourse, will probably be thinking that this sort of thing is all very well but without point unless accompanied by useful suggestion. "Mistiness," wrote Cardinal Newman, "is the Mother of Wisdom"; and it is easier to point out present imperfections than to devise future remedies. Nor is it often possible in India, a suitable field for prudent experiment if ever there was one, to state, in advance, that this economic measure or that is certain to succeed. Every Indian reformer ought to know of the famous city which had three gates. On the first the horseman read inscribed, "Be bold"; and on the second gate yet again "Be bold, and evermore be bold;" and on the third it was written, "Be not too bold." But though prudence is a virtue in co-operative workers excessive caution and lack of foresight are not; and if discussion does no more than promote intelligent thought it is not without benefit.

In conclusion, therefore, and for a brief space only, I would invite attention to the achievements of Japan in the field of agricultural and industrial co-operation, for it is a field in which she has earned universal praise and approval. An Italian observer, for instance, declares that the work of the Japanese in this direction "must be regarded as one of the most brilliant manifestations of clear sighted and orderly human activity."

It should be remembered that before Japan entered upon her present era of industrial development she had to meet exactly the same problem as that which now faces the agricultural and industrial pioneer in many parts of India. Japan had not enough labour; so she set to work to increase the population and, with the prospect of rising prices before her, the produce of the fields. In both these undertakings she has succeeded. Within a period of about years her population has doubled, while the amount of rice produced per head of population is greater than before. In the matter her food supply—we may exclude from consideration the temporary shortage caused by abnormal industrial activity during the war—Japan is short by only 5·6 per cent. of being self-supporting. gain, Japan is a country of small holdings, with a co-operative stem based upon that fact. Seventy per cent. of Japanese farmers possess land of an area less than 1 *cho* (1 *cho* = 2½ acres), while only per cent. possess land of an area of more than 3 *chos*. For this reason, although cultivation is intensive and the requirements of the rural Japanese are small, secondary agricultural industries, such as paper-making, are of great importance. It is generally held in Japan that the yield of these industries varies between 10 and 25 per cent. of that from agriculture pure and simple. Rural progress in Japan has been scientifically guided and has followed a symmetrical plan of campaign. Till recently the Japanese administrative unit was the village or, as we call it in India, the *mouza*. This unit, cramped and narrow, has been replaced by *aza* groups, containing as many as 19 villages. These local associations have their own measure of self-government under a council of village elders and enjoy considerable powers of taxation to meet expenditure upon works of local improvement. They are the points at which the agricultural, educational, co-operative, irrigation, and engineering experts of Government impinge upon village life; and there is no doubt that the sense of association and responsibility thus fostered has given a powerful impetus to the development of Japanese resources. It has been found that the enlargement of the parish and the creation of a new responsibility make an antidote to the stagnation produced by individualism, prejudice, and narrowness of ideas,—in short, by the peasant spirit. Every village group has three or four primary schools, its own agricultural association, council chamber, and circulating library; and 80 per cent. of Japanese villages have co-operative societies, more than half of which are for credit and are worked on the principles of unlimited liability.

The Japanese have been quick to grasp that any country which desires to make co-operation the means of its advancement must, sooner or later, meet with disappointment if it follows the plan of trying to fit square pegs into round holes. Some twenty years ago the cultivated land of Japan was, for the most part, sub-divided into small, narrow, and irregular lots, often imperfectly or not suitably irrigated and drained, with an insufficient and generally unreasonable system of roads. In order to increase the produce of the soil by means of irrigation and drainage and appropriate change in the kind of cultivation, to diminish the areas left unproductive as boundary land between two contiguous holdings, and to obviate all the inconveniences caused by the existence of numerous small lots belonging to the same proprietor but scattered over a large area, the Government of Japan passed a law for the readjustment of farm lands. This came into operation in 1900, and was amended in 1909 when it was taken up for consideration with the law governing the working of co-operative societies, upon which it has an important bearing. The latter law is good and comprehensive. It deals with a system which includes a Central Association of Co-operative Societies for the whole of Japan, federations of co-operative societies in the various provinces of the Empire, a Land Mortgage Bank for all Japan, 46 provincial agricultural and industrial banks and primary co-operative societies of all kinds. The organization is democratic and representative of all interests involved. and, even in a land of small holdings, it includes such institutions as the *beiken-soko*, or co-operative warehouses for *graded and selected rice*. The cultivator deposits his rice - which must be up to standard - and, in exchange, obtains a deposit warrant which he can discount at his co-operative bank. In 1910 the Japanese Government commenced to make use of postal savings which are entrusted to the Deposit Sections of the Department of Finance, circulating them in the shape of loans to the *Noko Ginko* (Provincial Agricultural and Industrial Banks financing co-operative societies) and to the *Nippon Kangyo Ginko* (The Land Mortgage Bank of Japan). The Land Mortgage Bank guarantees the bond issues of the Agricultural and Industrial Banks, and helps them to keep their resources fluid by discounting their paper.

It is, indeed, the opinion of competent critics that despite the poor reputation earned by Japan in matters of commercial morality, there is a definite endeavour afoot in that country to have in the rural districts better men, women, and children. The highest aim of rural progress is to develop the minds and hearts of the rural population, and in all discussion of the rural problem it is necessary not to lose in technology a clear view of the final object. This essential aspect of the co-operative movement has not been overlooked by Japanese statesmen.

AGRICULTURAL HOLDINGS IN THE UNITED PROVINCES.

BY

THE HON'BLE MR. H. R. C. HAILEY, C.I.E., I.C.S.,
Director of Land Records and Agriculture, United Provinces.

THE character of tenants' holdings in the United Provinces and the possibility of effecting some rearrangement in them with a view to facilitating the development of agriculture have recently been attracting some attention. The discussions on the subject generally proceed on the assumption that these holdings are, in the main, so far uneconomic in size and incompact as to preclude the adoption of many forms of agricultural improvement. But the information on the first of these points is very inadequate, and all conversant with the land records system of the provinces will appreciate the difficulty of arriving at any definite idea as to the size of the average holding. This was strikingly illustrated by the divergence of opinion expressed by witnesses appearing before the Indian Cotton Committee when questioned as to the size of a holding in the cotton-growing tracts. As a basis for discussion, therefore, regarding the desirability or otherwise of any rearrangement, it seems essential to obtain clearer information both as to the size of the holdings and the extent to which they can reasonably be said to be uneconomic in character. On the second point there can be no difference of opinion; yet it would often appear that the reasons which have led to formation of incompact holdings and the difficulties, from the point of view of cultivating the land, of consolidation are not clearly understood.

An attempt has accordingly been made to ascertain the size of the average tenant's holding in different parts of the provinces rom an examination of the village registers. These are, however, primarily intended to record the nature of the tenure and the rent payable by the tenants, and the arrangement followed not only does not facilitate an enquiry of this nature, but leads to some misunderstanding of the actual position.

This will perhaps appear most clearly if, before explaining the method adopted, the difficulties of extracting the information required from the registers are set out.

1. The *mahal* * and not the village is the revenue unit, and consequently a tenant may hold land in a number of different *mahals*, the records of which are kept separately.

2. The *khatauni*† is arranged by tenures, and a tenant may hold land under several tenures. Thus an energetic family may hold land as occupancy and non-occupancy tenants and subtenants of *sir*‡ or of other right holders, and each plot will be shown under a separate heading. Nor does the complication end here, since some of the temporarily held land may be taken on lease by a member of the group, other than the head of the family, and yet cultivated jointly.

3. In some parts of the provinces the villages are closely crowded together, and tenants hold land in more than one village.

4. The greatest complication is caused by the joint holdings. A number of persons may have rights to a particular plot: some of whom are shown as holding other plots separately, the cultivation being also separate. As an example, 13 persons were shown as having rights in 43 acres, of whom seven were also tenants, jointly with other persons not belonging to the first group, in seven other holdings which were found on inquiry to be cultivated separately. In these cases, the original holding has usually been subdivided by a private arrangement; such subdivisions not being recognized by the rules framed under the Land Revenue Act.

* *Mahal* is the area for which a separate agreement for the payment of land revenue is taken. It may be a single village or part of a village, or may include more than one village.

† *Khatauni* is a register of persons cultivating or otherwise occupying land.

‡ *Sir* is land held by a landholder under special privileges.

5. A striking feature in almost all village returns is the number of single fields, or small plots, held by persons not entirely dependent on their land. These comprise labourers in villages and towns, carpenters, blacksmiths, barbers, priests, etc. It is very doubtful whether these should be called "holdings" at all, and should not rather be classed as "allotments." The owners often do not own cattle themselves, but depend on their patrons or neighbours, or cultivate by hand labour. The inclusion of these plots would obviously reduce the area of the genuine holdings.

The net result of the above is often to lead to an underestimate of the size of the holding; since land held under different tenures or in different villages is not included in the calculation.

The only satisfactory method, therefore, appeared to be to take each group and ascertain from inquiry the extent of their holdings under various tenures, correcting the result and ascertaining areas from the registers. Allotments held by persons who do not depend entirely on agriculture have been excluded. This is a slow and laborious proceeding, and only a limited area in a few selected districts could be covered. But the conclusions, though very imperfect of themselves, can be supplemented by those arrived at by Settlement officers who have dealt with the question in their reports.

It is well known that the holdings in the eastern, or rice-growing portions of the provinces, are smaller than in the western, and the population is denser. On the other hand, in Bundelkhand, with an average density of only 218 per square mile, the holdings are too large for the tenants to manage with their very imperfect implements and many include a considerable proportion of fallow or waste. The latter tract was, therefore, excluded altogether, and district typical of other tracts selected for examination.

Gorakhpur was taken as fairly representative of the eastern rice-growing districts. Unao is a central district standing between the rice and cotton-growing tracts. Cawnpore and Mainpuri are fairly representative of the wheat and cotton-growing tracts; Meerut of the wheat and cane-growing tracts.

The results are set out below :—

District		Average holding (excluding allotments)		Area per plough
		Acres		*Acres*
Gorakhpur	...	3·19	...	...
Unao	...	5·00	...	5·5
Cawnpore	...	5·50	...	6·4
Mainpuri	...	4·90	...	5·6
Meerut	...	6·45	...	...

It may be mentioned that it was particularly difficult to arrive t any conclusions with regard to the Gorakhpur District, owing o the fact that large numbers of proprietors themselves cultivate and as tenants of other proprietors. For this reason no figures f the plough rate could be quoted; while those of the Meerut District are also said to be unreliable.

Taking the Settlement reports, in the Gorakhpur Settlement eport it was stated that no statistics were to hand showing the ctual number of occupancy tenants who were also tenants-at-will; ut figures were quoted to support the assumption that, if allowance vere made for land held under both tenures by the same individuals, he average would be about 3 acres.

In the Allahabad report the average was put down at 2·72 acres.

In the report of the Fatehpur District, which stands between Allahabad and Cawnpore, the Settlement officer wrote, "to obtain the average size of each holding, the total tenant area has been livided by the real number of resident holdings (non-residents being excluded). The resultant figure, *viz.*, 4·38 acres, is a small one and ndicates considerable pressure on the land."

In Shahjahanpur the average tenant's holding was said to be 5 acres, and the average number of acres ploughed by every plough was found to be 7.

In Pilibhit, a somewhat sparsely populated district, the Settlement officer from inquiries in various villages estimated the average area held by tenants at 7 to 8 acres.

The matter seems to have received most attention at the Moradabad Settlement, in which district the average holding's area was put down at 6·77 acres. It is stated : " Great care has been taken in the preparation of this statement. The numbers of real tenants are those obtained after eliminating all names which have previously occurred in the village, either in another *mahal*, or *patti*,* or under another section of the *khatauni*." In Agra, the average holding of an occupancy tenant plus his land as a tenant-at-will was estimated at 8·1 : that of tenants-at-will at 6 acres. The Muttra figures closely correspond. The Settlement officer of Saharanpur, who also carried out the Allahabad Settlement, writes that on the information to hand, which is by no means complete, the average holding of that district may be put down at about 8 acres.

It will be seen that there is a gradation in the size of the holdings from the west to the east of the provinces. To a certain extent this is connected with the relative density of the population, but, as the following figures will show, this cannot be the whole explanation :—

District		Population, per square mile
Meerut		648
Saharanpur		483
Moradabad		553
Mainpuri		476
Cawnpore		482
Unao ...		510
Allahabad	Eastern districts	513
Gorakhpur	Eastern districts	707
Basti	Eastern districts	653
Partabgarh	Eastern districts	624
Jaunpur	Eastern districts	746

Meerut with relatively large holdings ranks next in point of density of population to Gorakhpur ; while a number of districts have a heavier population than Allahabad where the holdings appear to be extremely small. Another explanation is afforded by the census figures showing the proportion of the population supported by agriculture alone and that supported by industries.

	Districts	Percentage of population supported by agriculture	Percentage of population supported by industries
Western	Meerut	55	21
	Saharanpur	44	22
	Agra ...	60	18
	Moradabad	62	18
	Cawnpore	59	14
	Mainpuri	66	14
Eastern	Allahabad	71	10
	Gorakhpur	88	4
	Basti	87	4
	Partabgarh	82	9
	Jaunpur	81	9

* Part of *mahal*.

Throughout the eastern districts the proportion of population ngaged in agriculture alone is high, and some diversity of occupation ould certainly appear to relieve the pressure on the land.

How far these holdings can be considered uneconomic must epend largely on the meaning attached to the term. It is somemes used to imply that the holding is too minute to maintain le occupants in reasonable comfort: sometimes, that its size and tuation do not admit of the application of the best methods of usbandry. But the expression must connote waste in some form; ther of the land, or of human or animal power. Whatever criterion applied, it will probably be admitted that holdings of 3 acres ust be classed as uneconomic for the production of staple crops; nd that they do not occupy, either fully, or to the best advantage, he human and animal labour. There is the additional disadvantage at the occupants, being barely able to get a livelihood from the nd, have no surplus to devote to any form of improvement. griculture thus does tend to stagnate in such tracts.

The case of a 5-or-6-acre holding is open to more doubt. This as large an area as one pair of bullocks can work properly with ell irrigation, and, looking to the diversity of the crops grown, he system of double-cropping which is customary even with cotton, uch a holding will keep a family of moderate size fully occupied. f enlarged to a two-or-three-plough holding, hired labour in proporion to the increase would be required. It seems somewhat idle to liscuss the optimum holding of a peasant farmer, since so much nust depend on a number of factors, such as the character of the oil, nature of the cultivation, facilities for obtaining water, etc. f not unduly small for present appliances, the inadequacy of a olding in the western districts might become pronounced with the ntroduction of improved implements.

As Japan is sometimes held up as an example to be followed in agricultural reorganization, it may be not uninteresting to compare the size of the holdings in that country. In the report of the gricultural Bureau published by the Department of Agriculture nd Commerce, Tokyo, it is stated: "It will be seen that when the rable lands in the country are distributed among each farmer's family, the average area is 1 *cho* 7 *se* in farm lands (slightly under three acres)—the fact that our farmers live on such a small area of land may be attributable to the utilization of the farm as two crops fields." The distribution is here by family, whereas in these provinces a holding is frequently cultivated by several families and allotments have been excluded. If the same method of calculation were followed, holdings in Japan would probably not be much smaller than the medium-sized holdings in the United Provinces.

The figures, however, quoted above do not set out the whole situation. Account has to be taken of two other factors: (1) the amount of sub-leasing which prevails; and (2) the size of some of the groups composing the cultivating units. The extent to which sub-leasing prevails varies very much in different parts of the provinces, being as high as 29 per cent. in the Benares Division and falling to 9 per cent. in the Meerut. Without quoting more figures, it may be said that it is most common among high caste tenants, and comparatively rare among the energetic agricultural castes, such as Jats and Kurmis. The right holder in such cases sinks into the position of a petty proprietor, leasing the whole or part of his holding to a subtenant. The latter is rack-rented and his position is precarious; his land is in consequence usually badly cultivated. The inquiry further showed that many of the cultivating units were composed of several families, sometimes as many as four and five. In some cases they cultivated in common: in others they had privately subdivided the land and, what is worse, cut up the fields. Such subdivisions not being recognized, joint liability for the rent remains and the whole area is treated as a single holding. The figures of holdings, therefore, are so far less favourable than they appear on the surface that the area may have to maintain an excessive number of persons, and the real unit of cultivation may be something smaller than the recorded holding. These features of the land system are due to the intense pressure on the land, and, so long as the same causes remain at work, must be reckoned with in any scheme for promoting agricultural improvement by enlarging the holdings. Legal restraints have proved inadequate to prevent wholesale sub-leasing and subdivision, and these tendencies, by lowering the al unit of cultivation, would cut at the root of any such scheme r reorganizing holdings.

Though greatly accentuated by the scramble for land and sub-vision of proprietary rights, fragmentation of holdings may often traced to the necessity of apportioning the land so that each larer had fields for cultivation at both harvests. In a typical ce-growing tract the villages cluster on the high land which is nder wheat or other spring crops, the low-lying flooded fields eyond being reserved for rice. Consolidation of holdings would ring the cultivator no nearer his land, unless the style of village rchitecture were so altered that he could live in the rice fields; hile it would have the disadvantage that the holding, instead f consisting partly of rice and partly of wheat land, would be nade up wholly of either one or the other. Owing to the irregularity f the monsoon, rice in the United Provinces is a most uncertain rop, unless irrigation is available. In those parts of the submontane istricts where water is near the surface and the land generally well uited for house-building, the villages are either closely packed to-ether or have broken up into a number of small hamlets. Here the nconvenience from incompact holdings is probably slight, and the uniform standard of the cultivation illustrates the advantages of he cultivator living near his work. It may be mentioned that the ultivators themselves most thoroughly appreciate this advantage, mainly because of the inconvenience of watching their crops when at a distance from their homes. Over, perhaps, the greater part of the provinces the difficulty of consolidation is one of water. The wells are usually in, or comparatively near, the village, the presence of a good water-supply possibly determining the site. A typical holding in such villages consists of a plot of land in the highly manured home land round the village, another in the middle zone less highly manured, but possibly irrigable from the wells—and a third in the outlying zone which is unirrigated and given up to rains crops. Such a distribution gives the cultivator a good diversity of crops, and keeps him occupied all the year round. Distribution of the land into compact holdings would only be workable provided wells were constructed in the outer zones, and boring experience shows this might not always be feasible. To take a man away from his water-supply to bring him nearer his work is a doubtful boon in India. At the same time there is no class of villages which would benefit more from a policy of consolidation of the holdings, if accompanied by the provision of a water-supply. The outlying zones are usually under poor and irregular cultivation, and there are often patches of waste between the villages. The establishment of hamlets—single homesteads would mean too many wells—would level up the standard of cultivation and bring fresh land under tillage. It might seem that the canal tracts offer the best opportunity for a policy of consolidation. This is possibly the case in some villages, but canal irrigation rarely extends over more than part of the villages in the United Provinces, and the same obstacle would arise, *viz.*, that some of the holdings must be entirely outside the irrigated area, to the ruin of the less fortunate in dry years. For the provinces as a whole, therefore, consolidation of holdings is, at present, a counsel of perfection ; but it could be carried out with great advantage in limited areas. When new wells are put down, or pumping plant installed to command areas hitherto either uncultivated or highly precarious, arrangements could often be made for dividing the land into plots of suitable size and letting it in compact holdings.

There would, too, be undoubted advantages in bringing together fields held by individual tenants in the same block, that is the rice or wheat-growing block, so long as the main distribution of the holdings among the different blocks were not affected. But such a measure would only be feasible if all the land were held in the same tenure and under the same proprietors.

The whole agricultural system of the provinces has in fact been adapted to meet the predominant feature of the climatic conditions, *viz.*, the uncertainty of the rainfall. This has led the agriculturist to aim at security rather than high results, and to frame his annual crop programme so as to eliminate the chances of total failure. This attitude may be seen in every phase of his operations—in the growing of two crops, often to the detriment of the main crop—in the habit of sowing mixed crops, to the despair of the statistician—in his preference for hardy, if low-yielding varieties—and, in the land system, in the distribution of the different classes of land so as to secure at least one crop in the year. It is not conducive to good agriculture; but it has enabled a dense population to meet with success the vicissitudes of the season. A change in this attitude can only be expected with a modification of the conditions which have forced it on the agricultural population, that is, as the gradual increase of protection lessens their dependence on the annual rainfall.

THE FRAGMENTATION OF HOLDINGS AS IT AFFECTS THE INTRODUCTION OF AGRICULTURAL IMPROVEMENTS.*

BY

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In a previous paper[1] read at the Indian Science Congress in 1916, some of the more general considerations affecting the re-alignment of agricultural holdings were discussed, and it was pointed out that the present system led to very great loss of agricultural efficiency. Since that time considerable interest has been shown in the subject, and the debate at the last meeting of the Board of Agriculture at Poona,[2] based on Mr. Keatinge's paper and draft bill, helped considerably to define the issues. Mr. Keatinge's paper rendered great service in one direction amongst others, by showing that the question of the size of the economic holding, though of great importance, was not necessarily identical with the prevention of fragmentation of holdings, although the two problems had often been discussed as one in the past.

In several districts in the United Provinces, there is good reason to believe that the average holding is somewhere in the neighbourhood of three acres. It is hoped that, in the near future, further data will be available, showing the number of holdings of various sizes in villages typical of certain tracts. As to what may be considered an economic holding will depend largely on the basis one adopts, and clearly the figure chosen must vary considerably with the nature

* A paper read at the Sixth Indian Science Congress, Bombay, January, 1919.

1 *Agricultural Journal of India*, Special Indian Science Congress Number 1916, p. 33.

2 *Proceedings of the Board of Agriculture in India held at Poona*, 1917, p. 26.

the soil, the crops grown, and the nature of the sources of irrigation. But for typical canal-irrigated land in the Cawnpore and adjoining districts, eight acres of mixed farming probably represents the area which can be managed with a single pair of *good* cattle to advantage. With wheat and cotton as the principal cash crops, and with the usual percentage of irrigation—the more important subsidiary crops being *juar* (*A. Sorghum*) with *arhar* (*Cajanus indicus*), gram, maize and some barley —this area also enables a satisfactory supply of fodder to be grown and would allow of fair provision of grain for the cattle. Many much larger holdings carrying several ploughs are known to exist, and also many much smaller. How far the smaller holdings are really uneconomic, and how far they represent the Indian equivalent of "allotments" cultivated by labourers who are only partly dependent on them, it is difficult to say; but one's general impression is that it is only as the country develops and other outlets for labour arise that the holding below the economic size will vanish. The small holdings held by labourers will probably always remain. The desire of this class to obtain land is often intense, as it often affords practically their only chance of social betterment.

But a compact holding of eight, or even six, acres is a vastly better proposition than the present type of holding of this size. Even if we admit that drastic action to limit the minimum size of holdings is at present impossible, there is no reason why steps should not be taken to limit the evils of fragmentation. In the districts referred to above, there is a very large number of holdings of undoubted economic size, varying from eight to twenty acres, with a smaller number of larger holdings, all of which would be capable of really good working were they reasonably compact. Many large occupancy holdings exist, but few of them are worked to the best advantage, and considerable portions of many of them are sub-let. Whilst there are often other reasons for this, particularly in the case of some castes, the writer has often been told by the tenants-in-chief that the sub-letting is due to the difficulties of managing a scattered holding, particularly of providing for the watching of crops. Thus we have potential farms sub-let in bits and lose an asset of considerable importance.

The same difficulty arises with the land of cultivating zemindars. The number of zemindars who own considerable areas of *sir* or *khudkasht* land, which theoretically form their home farms, is large, and such men are an important asset in the introduction of agricultural improvements, since they generally possess some education, and have a certain amount of capital, besides being extremely influential in their own circle. But here again any attempt at farming, as distinct from the cultivation of a miscellaneous collection of fields, is rendered the more difficult by the scattered nature of the land and the difficulties encountered in any attempt at obtaining compact areas. The writer has come across several cases where small cultivating zemindars, in an attempt to obtain a compact bit of land, have taken up and brought into cultivation pieces of waste or grazing land and have sub-let their old *sir* land. Such opportunities are rare, however, as the districts mentioned are closely populated, and there is little culturable fallow except where irrigation is non-existent or precarious.

A small experiment in the Cawnpore District has given us definite data as to the possibilities of small home farms cultivated by their owners. With the assistance of the department, a small Kurmi zemindar devoted the whole of his *sir*, and also some rented land, aggregating approximately 40 acres, to the growing of improved varieties of crops with the methods of cultivation adopted on our seed farm. Profitable though this was, he was convinced, in the first year, of the waste of labour and unsatisfactory results which resulted from scattered fields. After some trouble and with a great deal of assistance from the Collector of the district and his staff, a compact area was obtained by voluntary exchange with other zamindars and cultivators, but this was only achieved by the former giving up some of his best land and taking in exchange a block of land more remote from the village site and assessed as much less valuable. The results amply vindicated the value of a compact holding. The Irrigation Department were at once able to render important assistance as regards water-supply, economy in management was immediately apparent, and the crops of Pusa wheat, Cawnpore-American cotton and other crops raised were in no way inferior to those on our own farms. On the owner's own showing, and after allotting himself the usual rent on the land, the very useful *net* profit of Rs. 50 per acre was obtained. Unfortunately, under our present Rent Acts, it is not often possible to arrange compact holdings by agreement.

In discussions which have taken place on this subject, it has been impossible not to notice a feeling, on the part of some revenue officers, that the agricultural departments are going outside their own sphere in taking up a matter which they view as primarily economic, and that the departments would do better to restrict their energies to more purely technical matters. Were this view based on correct assumptions it would temporarily carry some weight, as the agricultural departments are admittedly under-staffed and already have on their hands as much as they can manage. Apart from the fact that all means of rural betterment must come eventually within the consideration of the departments charged with agricultural development, there is the more immediate point that fragmentation of holdings imposes distinct limits on the introduction of agricultural improvement. Whether it be the introduction of a new crop, new variety, or improved method, it should be possible—once the proposed improvement has been well worked out on an experimental farm and proof given that it can be profitably employed, and that it involves nothing beyond the means of a well-to-do cultivator—to proceed unhesitatingly with its introduction. This, however, is not the case. When farm testing is extended to village testing, failures occur as the result of conditions which ought not to exist. The writer has had under his notice several varieties of cotton with distinctly desirable commercial qualities and with apparently the necessary agricultural characters to ensure high yield, which, given ordinary decent cultivation on departmental farms, have yielded well enough, but which under village conditions, through water-logging caused by inadequate surface drainage, have done badly. This led to the conclusion that the local *desi* cotton possessed a certain degree of tolerance to water-logging which had not previously been considered of importance. Now the production of an improved staple crop is a sufficiently difficult and lengthy process as it is. The number of characters to be dealt with is considerable, and every additional character to be considered makes work more difficult and slower. If it is also necessary to consider a somewhat indefinite character, which only appears under faulty conditions of cultivation, progress is further delayed. In many villages inadequate surface drainage is purely a matter of small and scattered fields. With compact, if small, holdings, great improvement would be possible at nominal cost. Is one not justified in attacking the problem from both ends?

What has been said of cotton is equally true, though to a less marked extent, of wheat. An improved wheat is, in a sense, a more efficient machine, and unless it is given the cultivation necessary to achieve high yields, its full value will not be obtained. Nor can wheat of high milling quality be grown on ill-drained land. This point has been strikingly brought out by the result of crop cutting experiments on Pusa 12 wheat in villages. Instead of a possible yield of 30 maunds per acre on really fertile land and 25 maunds per acre on average land (as compared to the district's normal 16 maunds of *desi* wheat), many cultivators were getting only 19 maunds per acre, or one-third of the possible increase. In the same villages higher yields were being obtained on well-cultivated or well-situated fields. The effect on quality was almost as marked, though complicated by excessive irrigation in some cases.

Such examples could be multiplied. Scattered holdings usually mean small fields, and even if drainage is not interrupted, such fields are difficult to plough correctly or to cultivate well. One is justified in asking whether such changes in the tenancy laws are not possible in zemindari provinces, as will enable those who realize the advantages of compact holdings, to take steps to get them, and will reduce the present tendency to further fragmentation.

AGRICULTURE AND IRRIGATION: A PROBLEM OF ECONOMIC DEVELOPMENT.

BY

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"WHEN I hear the simplicity of contrivance aimed at in any ew political constitutions, I am at no loss to decide that the rtificers are grossly ignorant of their trade, or totally negligent f their duty. It is better that the whole should be imperfectly nswered than that, while some parts are provided for with great xactness, others might be totally neglected, or perhaps materially njured, by the over-care of a favourite member."--[*Burke's Reflections on the French Revolution.*]

The above observation is as much true of other institutions as of political. Civilization is getting more and more complex, and its component parts, and eventually the whole, suffer for want of co-ordination and neglect of the less favoured ones. The science of agriculture has long suffered from neglect. Up till very late, agriculture was supposed to be the business of the illiterate cultivator. I have no desire to find fault with the Indian cultivator for not knowing better. Indeed, it is a matter of surprise that, born and bred in ignorance, he yet contrives to be so successful in agriculture, by following the principles which have descended to him in an unbroken chain for thousands of years from his forefathers, but his primitive methods are unsuited to the present conditions of rapid development. India should be grateful to Lord Curzon for having created an Agricultural Department and encouraging research. The Indian States, too, have not been slow to follow in the wake of the Government. I am not in the Agricultural Department and hence have no right to express any opinion about matters agricultural, but the relation between agriculture and irrigation is so intimate and indissoluble that my remarks, I trust, will not be considered out of place. Indeed, only on the establishment of correct relation between the departments of revenue, irrigation and agriculture the economic development of our vast areas is possible. At present the three departments work, more or less, in water-tight compartments. Each regards the criticism of the others as meddlesome. Criticism is always valuable, but to achieve its ends it should be constructive. The attitude of armed neutrality, almost hostility, exhibited by these allied departments towards each other, is not unnatural under the existing rules and circumstances. That far-sighted statesman who would blend the activities of all these into one homogeneous whole has yet to come. It will be his duty to show that the best interests of every one of them can only be attained by co-operation and co-ordination.

Once upon a time the different members of the human body rebelled against the stomach. The eyes thought that the whole body would be useless without their service. The legs raised an uproar that if they refused to work the body would die of inanition. The hands similarly vociferated that the entire civilization was built by them. In short, each component part of the body asserted its importance, but all were agreed that the stomach was not only useless but a wasteful luxury. It consumed and appropriated the best of what the world could produce. All the rebels struck work and gloated on the discomfiture of the stomach. The poor stomach collapsed, but being wise held its peace. As it took no food, it could send no nourishment on to the different organs whose functions began to suffer. The eyes grew dim, the legs began to totter, the hands lost their nerve, and every limb was in distress. The rebels very soon came to their senses and realized that while all of them were doing their respective duties in the human economy, the stomach had its uses too, and that the well-being of the whole depended on the well-being of all the parts. This is a homely parable, but it applies in full force to the unco-ordinated and exclusive activities of the allied partments of revenue, irrigation and agriculture. If the Revenue Department were to act more considerately in its dealings with its sister departments, and were more ready to accept the advice of irrigational and agricultural experts, and these, in their turn, accepted their interdependence on the Revenue Department, we would not see so many lakhs of acres lying uncultivated, and the present criminal waste of water and harrowing visitations of famine will become a thing of the past. The existing irrigated area in India is about 0 crores of acres. It does not require any effort of imagination to see that this could easily be doubled if the results of the researches of the agricultural experts were given due weight by the irrigation and revenue officers.

Plants are living organisms. They require food, water and air. The soil supplies the main portion of the food, irrigation works supply water, and the air is there in abundance if the cultivator only knew how and when to supply it to the roots. At present water is supposed to be the panacea of all evils. If the soil is poor, water is supposed to make it fertile. If there is excessive heat, water is called upon to reduce it. Water again is called into requisition to counteract the rigours of cold. Water does all this, but more is required than water. The roots require air as well. There is such a thing, Mr. Howard rightly says, as poisoning the roots with too much water. It will be unnecessary for me to dilate on this point, as this aspect of the subject has been well brought out by Mr. and Mrs. Howard of Pusa in their Bulletins,[1] which are important enough to be studied by every irrigation and revenue officer.

Over-irrigation and wasteful application of water produce harmful effects in several ways—

(1) by reduction in the yield of crops per acre;
(2) by impoverishment and deterioration of soil;
(3) by spoiling the climate, rendering it too humid and malarious;
(4) by rendering irrigation works less efficient and consequent loss of revenue.

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[1] *Agric. Res. Inst., Pusa, Bull. Nos. 52 and 61.*

Leaving aside the minor harms of over-irrigation, if we try to appraise the monetary value of the above factors only, it would, for India as a whole, run into millions of rupees. Over-irrigated crops yield about half of seasonably-irrigated ones. When we see that all irrigated area is more or less over-irrigated, this factor alone is potent in reducing the total outturn and, in consequence, the wealth of the country. The damage caused to the soil and to the future generations can only be realized on observing the condition of water-logged areas. The effect on climate cannot be expressed in money, but the loss to India of valuable lives by malaria is very great. Malaria is a slow and insidious disease, and does not attract that attention which cholera, plague and similar epidemics do, but it claims more victims annually than all of these put together! Is it not therefore worth our while to harken to the friendly voice of the agricultural experts, and modify our ways of irrigation and cultivation? I am not a theorist, and fully realize what this means. This means a revolution in our present methods of cultivation and irrigation; no more and no less. It would necessitate overhauling and remodelling the entire irrigation systems of India on which crores have been spent. This is a gigantic task, sufficient to stagger the imagination of the engineers; but if we want to develop India economically, the difficulty must be faced, and the sooner we do it the better. It will also give food for thought to the financiers. They might well grumble at having to loosen their purse strings, but the war has amply proved that parochial methods of financing are no longer tenable and must be discarded, and higher finance should be allowed full play if nations do not want to lag behind in the race of advancement. The present difficulties must not be allowed to cripple the future. Financing and construction of large irrigation works are, at present, considered apart from each other. This is incorrect. They must be considered together. Readers of this article will do well to study Professor Stanley Jevons' article on the "Art of Economic Development" in the January (1918) Number of the *Indian Journal of Economics*.

Engineers flushed with the success of their enterprises are rather impatient of criticism of their method from agriculturists, but if latter continue to follow their propaganda with persistency, it not take them long to get a patient hearing and convince the gineers of the value of their researches.

Mr. Howard lays great stress on reducing the numbers and pths of waterings, and he has tried to show that if the soil is in per tilth. and proper root-aeration and soil ventilation are carried , it is quite possible to raise wheat on one watering in alluvial cts. Much more so is it possible in black soils of Malwa, owing their greater retentiveness. He is of opinion that this can automatically be achieved by supplying water by measurement. This certainly the goal to be aimed at, but I am afraid it would be too dy for the primitive conditions of India, where the agricultural asses are illiterate and ignorant. It is carried out in America and s proved a great success, not only in economizing waste of water, t in reclaiming water-logged tracts.

Up till very late, it was usual in Gwalior to allow for a duty 20 bighas (10 acres) per million cubic feet of the water stored. This cluded all loss in transit and worked out to a depth of 26 inches. is was of course very rough and encouraged waste in application. r as long as the staff attained this duty, their work was considered tisfactory; but recently, with a view to minimize loss in application d to arrive at a juster estimate of the irrigation possibilities of our orks, I have laid down the following scale, which is only applicable r small projects with length of channels up to 10 miles :--

able showing the duties of one million cubic feet of water for different crops.

rial No.	Name of crop	Duty per million cubic feet: Impervious soils	Loamy soils	Sandy porous soils	Remarks
	A. Kharif	Bighas	Bighas	Bighas	
1	Rice ...	30	20	10	
2	Cotton ...	90	60	45	
	B. Rabi				
3	Wheat ...	65	40	20	
4	Gram and other pulses ...	180	125	70	
	C. Perennial				
5	Sugarcane and gardens ...	15	10	5	

For large projects, with lengths of channels ranging from 10 t 100 miles, a different procedure is adopted. Before determinin the carrying capacity of the main canal and its distributaries, it i in view of local conditions, fixed what proportions of differen crops will be developed in the tract under consideration. This, c course, is a rough approximation, but answers all practical requir ments. The proportion having been settled, the quantity o water for *kharif* and *rabi* crops is worked out from the followin standard numbers and depths of waterings. As far as possible, th *kharif* and *rabi* crops are so balanced that they require about th same discharge. As the Gwalior canals work alternately fro June to October for *kharif*, and October to March for *rabi* crop it is evident that the capacity of maximum economy is attained b balancing the *kharif* and *rabi* discharges :—

Standard numbers and depths of waterings.

Name of crop	No. of waterings		Depth of waterings		Remarks
	Impervious clay	Porous loam	Impervious clay	Porous loam	
1. *Kharif*—					
(*a*) Rice ...	4	8	2"	4"	The waterings i the *kharif* sea sons are in add tion to water sup plied by rains.
(*b*) Sugarcane ...	4	6	2"	4"	
(*c*) Cotton ...	2	3	1½"	2"	
2. *Rabi*—					
(*a*) Wheat ...	2	4	2"	3"	
(*b*) Gram ...	1	2	1½"	2"	
(*c*) Sugarcane ...	5	8	2"	3"	

The above depths of waterings are on the fields. Loss i transit on large canals is considerable. On the basis of experienc acquired in the Punjab, the loss for evaporation and absorption allowed for at the rate of 10 cusecs per million square feet of wette area. It is hoped that with the introduction of this procedure, a more careful supervision and encouragement of a single waterin it will be possible to greatly reduce waste in Gwalior canals an increase their efficiency. That this is working satisfactorily clear from experience gained on the Bhind canal. The storages o the Sank-Assan scheme aggregate to 10,000 million cubic feet. M Preston considered these would suffice to irrigate one lakh bighas (

)00 acres. This gives a theoretical duty of 10 bighas per million ic feet, but during the last three years the duty attained is about ible of this.

Charging by measurement in India is a bit too early. The rest approach to it is charging by the number of waterings. In British provinces, the Irrigation Department charge for crops tured. In the Irrigation Act of Gwalior, the State has wisely, my recommendation, allowed charging 8 annas per bigha for single watering. In black soil tracts, irrigation is unpopular, as ing to their retentiveness no watering is generally necessary for bi crops, and in years in which the rainfall is not well distributed, fails in October or in winter, one watering is needed. The irri-tor is averse to pay R. 1-8 for one watering. The provision of 8 nas for a single watering comes in very handy and is slowly leading the extension of irrigation in Malwa. In Irrigation Paper No. 15 Development of high class crops in black cotton soils in Malwa"), have tried to explain to the revenue officers and the cultivator at the *raison d'être* of the irrigation works is not merely to mature *arif* and *rabi* crops, but (1) to provide water for domestic and inking purposes, as there are no sub-soil springs: (2) to supplement infall in years of drought; (3) to raise high class crops like sugar-ne, paddy and opium, requiring not only a larger number of water-gs but water at the fag end of the irrigation season (May or June), hen water can only be had from irrigation works; and (4) to increase e yield per bigha and improve the quality of *kharif* and *rabi* crops. have attempted to show in that paper that because *rabi* and *harif* crops of inferior sorts can be raised without artificial irriga-on, it is no argument against other legitimate and more paying ses of water. It is difficult to pierce the thick skin of the Indian ltivator, especially as it is covered with a layer of ignorance of ages; ut he is shrewd enough to understand what touches his pocket. his is why the advantage of paying 8 annas per watering is owly sinking into his consciousness, and he is taking more and more ater, not because my arguments have convinced him, but because sees that it is to his advantage to extend irrigation by comparing e results of single-irrigated fields with those of the non-irrigated ones. The advantage of a single watering would be more in evider if he knew something about the soil atmosphere and the necess of soil-aeration and root-ventilation. This is partly done by Nat in Malwa, as the black cotton soil gets badly cracked and permits penetrating to the roots. This quality of fissuring, perhaps, accou more for the proverbial fertility of black cotton soils of Malwa th any inherent quality.

This subject is a vast one and would require a volume to justice to it. I have in this short article endeavoured to mere break ground. We have much to do. It is high time the activit of the allied departments of revenue, irrigation and agricult were correlated to the great improvement of agriculture, amel ration of the condition of the ryot, and general increase in the wea of the country.

;EQUENT FAILURE OF A LARGE PROPORTION OF THE RICE CROP IN CHOTA NAGPUR.*

BY

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THIS paper refers primarily to the Ranchi District, but is licable to other large areas of Chota Nagpur where the physical ditions are similar.

The Ranchi District consists, in the main, of plateaus at three ations, 1,000, 2,000 and 2,500 feet, respectively, above sea-level. area of the district is over 7,000 square miles, and the average fall about 53 inches, of which some 45 inches fall within four iths.

The soil of the uplands appears to be derived *in situ* from weathering of the gneiss which forms the great mass of the rock the plateaus, and consists for the most part of clay in which ticles of coarse sand are embedded. When the fine particles of y are washed out of the surface soil the residue is distinctly sandy, l acts as a superficial reservoir in which a considerable part of h monsoon shower is held and enabled to soak at leisure into the pervious sub-soil, whence it can only escape laterally over the npact rock below.

This lateral movement is very slow, and a ridge of any considerle dimensions holds enough water in the sub-soil to supply springs the valleys round it throughout the year, while in the monsoon e water frequently comes to the surface at a comparatively short

* A paper read at the Sixth Indian Science Congress, Bombay, January, 1919.

distance from the crest of the ridge, on land that appears to the casual observer remarkably high and well drained.

The soil conditions present a marked contrast in this respect to those of alluvial plains where the coarser and more pervious layers having been deposited first are found, generally speaking, below, and the finer and less pervious layers above, with the result that lateral drainage is more rapid in the lower strata, the sub-soil water rising and falling with the level of the rivers with which it is in reciprocal relations.

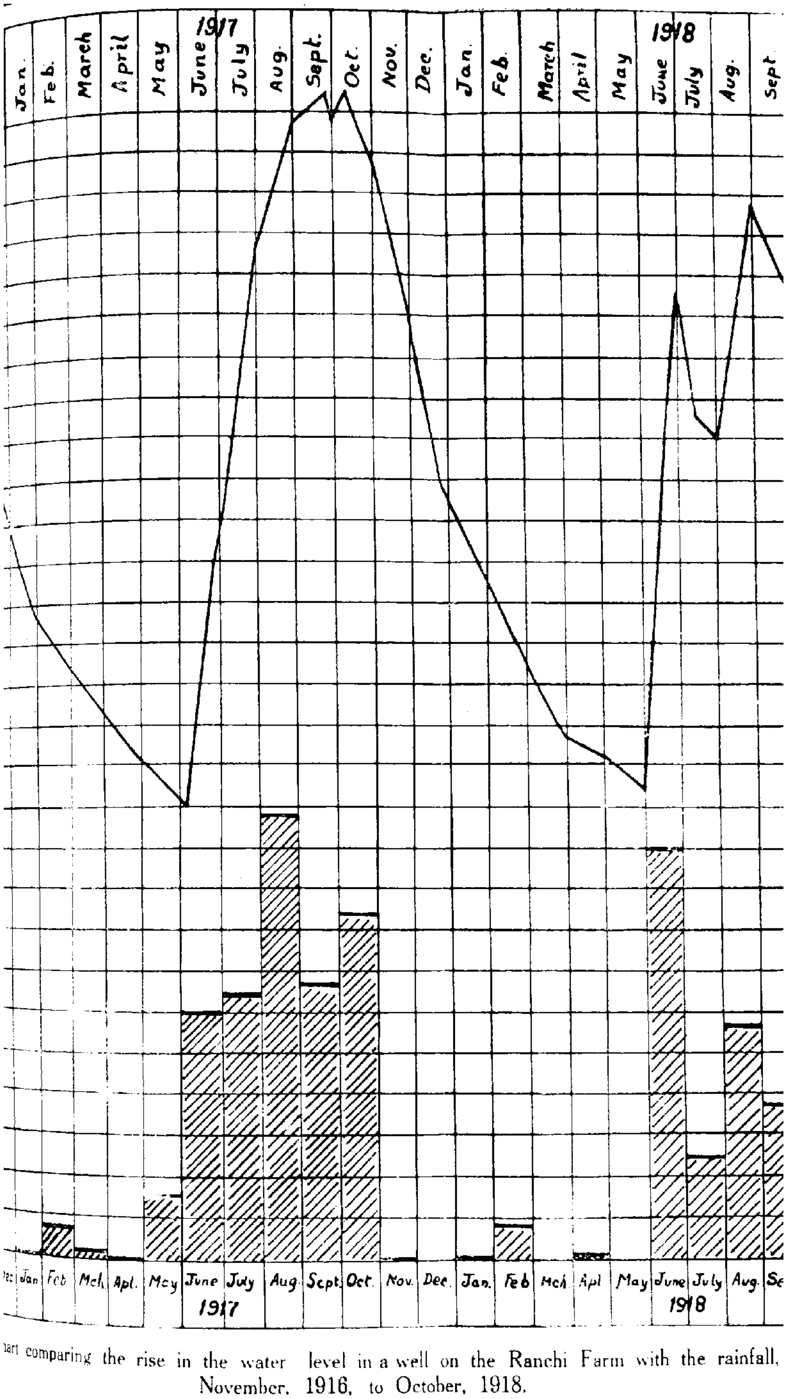
In Chota Nagpur, wells depend on the local rainfall, though they are frequently sunk into the weathering gneiss until it becomes so compact that further sinking is obviously useless.

The graph opposite shows the rainfall and the corresponding variation in the water-level in a well on high sloping ground on the Ranchi Farm. During September, October, and part of November 1917, the distance of the surface of the water from the top of the well was measured daily. The immediate rise of the water-level after rain is remarkable and may amount to five times the rainfall, as for instance on 19th and 20th September, 1917, when the water in the well rose 22½ inches as a result of 4·28 inches of rain. On the other hand, the rate of fall even from a high level is comparatively slow—38½ inches in 30 days without rain in November, the monsoon having continued up to the very end of October.

As will be seen later, this slow fall of the sub-soil water-level is a point of some importance in connection with the protection of the paddy crop against drought.

Another point of interest is the rapid rise of the water-level at the beginning of the monsoon—6 feet from 12 inches of rain in June, 1917, and 10 feet from 20 inches of rain in June, 1918. This may be partly due to the filling to overflowing of a tank within 200 yards diagonally across the slope.

When the sub-soil water-level is close to the surface over large areas in the latter half of the monsoon, heavy showers are unable to soak in to any considerable extent, and the water escapes almost immediately over the surface to the lower levels, eroding the valleys and causing sudden floods such as those of the Damodar which



art comparing the rise in the water level in a well on the Ranchi Farm with the rainfall, November, 1916, to October, 1918.

drains the greater part of the Hazaribagh and a corner of the Ranchi plateaus.

The comparatively level winding grooves ground out of the general level by this great volume of water charged with quartz and, open out through deep nullahs and narrow valleys into scalloped basins on the surface of the plateau, separated by ridges and

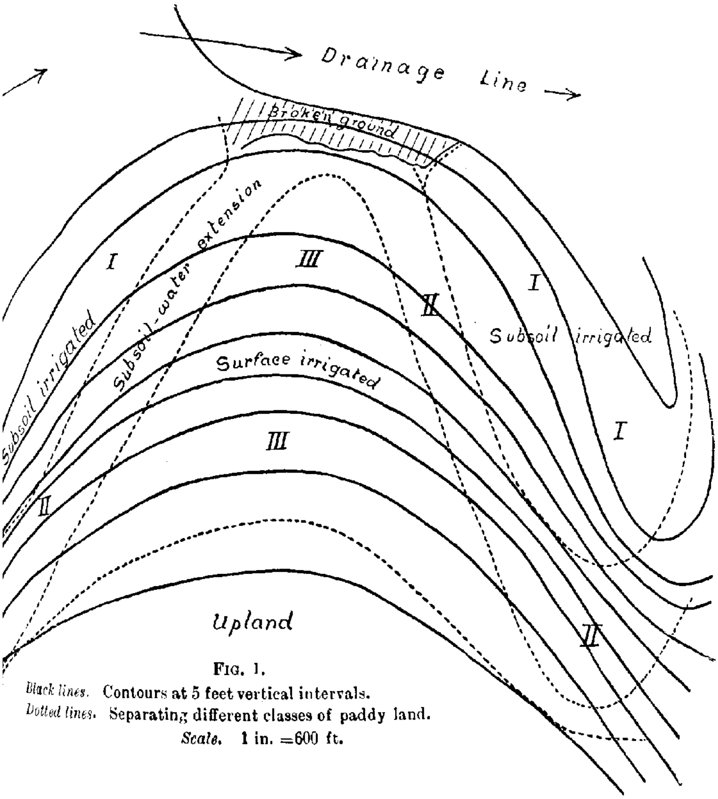


FIG. 1.
Black lines. Contours at 5 feet vertical intervals.
Dotted lines. Separating different classes of paddy land.
Scale. 1 in. =600 ft.

bluffs none of which extend laterally for more than half a mile or so from the nearest distinct drainage line. The diagram, Fig. 1, illustrates a very general arrangement of the contour lines on a bluff, and Fig. 2 the position of the sub-soil water surface relative to that of the ground at the end of the monsoon. Vertical distances have

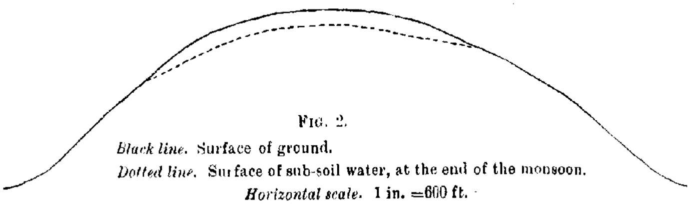


FIG. 2.

Black line. Surface of ground.

Dotted line. Surface of sub-soil water, at the end of the monsoon.

Horizontal scale. 1 in. =600 ft.

Vertical scale. 1 in. =30 ft.

of course, been greatly exaggerated to enable the eye to appreciate differences in level, which in reality rarely exceed 1 in 10 even on the most steeply terraced land.

It will be noticed that the dotted line representing the sub-soil water surface at the end of the monsoon in Fig. 2, comes to the surface of the ground at points somewhat above the points of maximum inclination of the slope, where the convex surface of the bluff merges into the concave surface of the basin on either side. The sub-soil water comes perforce to the surface in the neighbourhood of these points, where the disintegrating upper strata, through which the water must flow over the rocky core of the bluff, have been reduced to a minimum thickness by the rush of water from the relatively level surface above to the relatively level surface below.

The line where the sub-soil water emerges on the surface—in fact the spring-level—towards the end of a normal monsoon, marks what may be called the natural upper limit of paddy cultivation in Chota Nagpur. Starting at the head of each valley basin, the line runs down the sides of the bluff, on either hand cutting the contour lines at a considerable angle and emerging in the valley below as the bluff narrows to its apex.

A short distance below this line winter paddy may be grown with safety, in the assurance that the water stored in the sub-soil of the bluff above will rarely fail to maintain a steady supply up to November on the surface below.

Cultivators have, however, terraced the surfaces of the bluffs above this line up to a second line cutting the contours at a smaller angle and frequently encircling the bluff above its apex. Hardly anywhere in the Ranchi District have tanks been made in which water might be stored for irrigating these higher terraces, and, situated above the level of the sub-soil water in a normal season, they depend for flooding on the rain-water running off the upland and, at a lower level, on the surplus water from the higher terraces across the slope ; and they dry with every break in the monsoon. This area normally grows a light crop of early varieties of paddy which flower at the end of September and ripen off rapidly when the land dries, usually in October, but which suffer severely from any curtailment of their short growing season, and give practically no crop if the land cracks before they flower and is not quickly flooded again.

We have then two distinct classes of terraced paddy land in Chota Nagpur—the sub-soil-irrigated area which can be relied on to give a fair crop of winter paddy on the concave surfaces of the valley basins, and the surface-irrigated area which grows a small precarious crop of early varieties on the lower portions of the convex surfaces of the bluffs. Between these two areas, at about the normal monsoon level of the sub-soil water, lies a belt which may be described as the sub-soil-water-extension area, over which the sub-soil water is maintained at a high level by the storage of water in the fields themselves and on the surface-irrigated area immediately above.

This belt usually lies on a more or less plane surface and, where the slope is gentle, may be of considerable width ; it grows early winter paddies the yield of which is subject to considerable but rarely extreme fluctuations according to the character of the season, the land being kept moist after the close of the monsoon by the water percolating slowly from the sub-soil behind.

These three classes of land are separated in Fig. 1, from one another and from the upland by dotted lines, and are marked I, II and III from the lowest upwards.

In the Settlement Report of the Ranchi District, written by Mr. J. Reid, I.C.S., and from which all the statistics quoted in this paper have been taken, the terraced or "Don" paddy land is divided into four classes. The lowest of these, which grows two crops in the year, is classified as Don I and is said to cover an insignificant area of 760 acres in the whole district. This with Don II, which is said to grow the winter crop cut at the end of November, presumably covers the greater part of the area referred to here as sub-soil-irrigated : Don III, said to grow the crop cut early in November, seems to correspond with the intermediate belt which has been described as the sub-soil-water-extension area ; and Don IV, the crop on which is cut in October, must represent the surface-irrigated area which dries immediately after the monsoon ends.

Neglecting Don I as insignificant, the respective cropping power of these classes of land is estimated at 19, 15 and 9 mds. (of 80 lb.) to the acre in a normal season.

Now in a year like the present when the monsoon ends before the middle of September while the temperature is still high, the whole of the surface-irrigated area (III) dries to the point of cracking within about a fortnight, before even the earliest paddy flowers, and the crop on this area is practically a complete failure. Moreover, the intermediate belt (II), though drying comparatively slowly, carries a later crop and suffers to a less degree only, and as it normally gives a much heavier yield than the higher terraces the absolute loss per acre may be as great or even greater. Again the sub-soil-irrigated area (I), though rarely suffering from absolute drought, carries a still later and heavier crop which, in extreme cases, even if the lower half be entirely unaffected, must give a considerably smaller absolute yield along its upper margin.

The combined areas of Dons I and II (I) is, however, estimated at only 284,000 acres in the Ranchi District, while that of Dons III and IV (II and III) is 489,000 acres ; so that a partial failure of part of the crop on the lower land cannot do more than aggravate a situation that must be already serious. For, supposing that practically the whole normal crop of 9 maunds per acre on III is lost and also half of the crop of 15 maunds on II, we have a reduction of over 8 maunds per acre on 489,000 acres, or about 4 million maunds out of a total normal estimated production of 12¼ million maunds of paddy of all kinds, of which total some ¼ million maunds is exported educting a dead-weight of about a million maunds required for seed purposes, we find that the amount of paddy available for food purposes may be reduced from $11\frac{1}{4}$ million to $7\frac{1}{4}$ million maunds by the reduction of the crop on areas II and III alone, simply owing to an abnormally early closing of the monsoon even if the season has been otherwise favourable.

As the value of the paddy crop is estimated at 140 out of the 196 lakhs of rupees which represent the total value of the crops of the district, and as the aboriginal cultivators have practically no reserves, it can readily be believed that scarcity amounting to famine must prevail in many parts of Chota Nagpur under these circumstances. This is in fact frequently the case. To quote from the Settlement Report already referred to, "There was scarcity, if not famine, throughout great parts of the district in the years 1896, 1897, 1900, and again in 1908......The cause was in all cases the same, *viz.*, the early cessation of the monsoon."

Scarcity must, therefore, be described as of common occurrence, and it is liable to be greatly aggravated by the vagaries that are common in an abnormal monsoon. For instance, in the season that has just closed, drought up to the end of May and excessive rain (20 inches) in the first four weeks of June prevented the normal broadcast sowing of half the paddy area, and it was sown late and on wet land. The same was the case with the seed beds. This was followed by seven weeks with a total of less than $8\frac{1}{2}$ inches of rain, during which transplanting was only possible on an insignificant area. The whole paddy area therefore started about a month late and would in any case not have given more than two-thirds of the normal crop, even on the lowest land, while the crop on the intermediate area (II) and on the higher of the terraces below it, was only just coming into flower when the land began to crack, and in many places was not much better than the total failure on the higher terraces.

That such common and comparatively small fluctuations of the monsoon should have such a serious effect on the food supply of the district, is due primarily to the fact that the fluctuations are irregular and cannot at present be foreseen. The increasing accuracy of the monsoon forecasts gives some hope that it may ultimately be possible to adjust the sowing of early and late varieties of paddy, so that their flowering may in all cases precede the retirement of the monsoon. But common prudence suggests that it is foolish to continue to grow a very large proportion of the food supply under the artificial conditions implied by the sowing of a water-loving plant on land subject to sudden drought, without providing some means of supplying water for the comparatively short periods during which an artificial supply is commonly required even in a normal season.

As mentioned before, there are very few tanks and there are no natural lakes in the Ranchi District. That this is so is probably due partly to the generally steep gradients, which necessitate the making of very high embankments to retain any considerable areas of water. So far as Government action is concerned, sites where large tanks could be made with economy are not easy to find, and the equitable distribution of water on relatively small areas is full of administrative difficulties.

But if the safety of the paddy crop depends primarily on the maintenance of the sub-soil water at a high level in the bluffs, as the considerations detailed here indicate, it is not a few large tanks at the heads of valleys that are required, but a general distribution of small tanks along the slopes. And the function of these tanks would be not directly to irrigate the surface, but to hold up the water so that it would soak by itself into the fields below, through the sub-soil, without any necessity for regulation.

This is, in fact, the normal function of tanks in Chota Nagpur. They do not commonly hold water for any length of time above the sub-soil water-level, and are rarely used for irrigation in the ordinary way, but there is always a stream of water running out of the paddy fields immediately below them.

Beyond providing an emergency outlet at a high level it would therefore be unnecessary to take any steps to regulate the escape of the water, the distribution of the tanks thus solving most of the difficulties of administration.

The effect of such a tank, filled intermittently by monsoon showers, and leaking continuously into the sub-soil on all sides, is to ise the sub-soil water-level both above and below it, and thus to ovide, in the sub-soil, an additional reserve of water, which lasts r a much longer period than that for which the water held in the nk itself at any one time would suffice. This is well illustrated oth by the rapid rise and slow fall of the water in the well already ferred to, and, in a more practical and convincing way, by the case f another tank on the Ranchi Farm, made by running a *bandh* cross the lower side of a recessed paddy field surrounded by upland n the other three sides. Three or four inches of rain, falling in heavy howers at the beginning of the monsoon, fill this tank to a depth f about three feet. This disappears completely in about a fortnight f there be no further rain ; at the same time the water comes to the urface in the paddy fields below the tank which are completely dry n the hot weather. At the end of the recent monsoon the water ell to a depth of 3 ft. 8 in. below the outlet during 36 days of drought with a west wind, the level being maintained by visible percolation from the sub-soil above the tank. The rate of fall was thus almost exactly the same as that of the water in the well after the close of the previous monsoon.

Given a sufficient total rainfall, the maintenance of the sub-soil water-level for three or four weeks of dry weather, at a height sufficient to flood all the paddy fields, is therefore merely a question of holding up a sufficient quantity of the water of every monsoon shower, at a high level, immediately above the area to be protected. Experience on the Ranchi Farm seems to show that to fill up the sub-soil in the course of two months with a combined rainfall of about 20 inches, it is only necessary to hold up about 4 inches at any one time of the rainfall from over the collecting area. Assuming a radius of 500 yards of upland on the bluff, tanks 100 feet wide round the perimeter would be required to hold less than 5 feet depth of water for this purpose, and a 7-foot *bandh* would be sufficient—to be raised later if experience showed that it would be economical to do so. If a row of narrow tanks were made along the edge of the upland above the highest series of paddy fields, by excavating part of the slope to make a series of *bandhs* within 100 feet of the excavation, and in echelon along the slope, these tanks would go a long way towards tiding the paddy over the short periods of drought that are now so disastrous. Earth can be excavated and carried within a distance of 100 feet at a cost of 4½ annas per 100 cub. ft. in the Ranchi District, and a *bandh* 7 feet high and 21 feet wide at the base, with the necessary cross *bandhs* between the successive levels, could probably be made at a cost of annas 5 per running foot of tank.

The benefit would not be confined to the saving of the crop on the higher terraces in case of an early cessation of the rains, but by supplying water throughout any probable break in the monsoon and by enabling later and heavier yielding paddies to be grown with safety on the intermediate terraces, such a series of tanks would increase the crop over the whole commanded area by an amount that can hardly be put at less than 4 maunds an acre on an average of years. Taking the value of paddy at Rs. 2 a maund a simple calculation shows that an expenditure of Rs. 100 on 320 feet length of tank, involving an annual charge of, say, Rs. 20 for interest and repairs, would be justified by an average breadth of 350 feet of the area commanded.

The actual breadth of the paddy belt round the sides of a bluff is commonly very much greater than this, while there are wide expanses which though they could not be thoroughly protected without much greater expenditure, would give a greater proportional return for such partial protection.

Such protection being therefore well within the bounds of economic possibility it may be worth adding a few suggestions as to details and incidental possibilities.

A series of these narrow tanks would extend from the valley head on each side of a bluff, and would meet at some point above the apex of the bluff. If each tank were provided with a wide emergency outlet into the paddy field above and behind it and below the previous tank in the series, and were connected with the next lower tank by a narrow deeper cut for lesser showers, the run off from the collecting area could be effectively controlled by ensuring that a sufficient proportion drained into the higher tanks of the series. The proportion of water escaping through the several emergency outlets would be relatively unimportant, as they would only run when the rainfall was sufficient to flood the whole area to excess. There should be no difficulty in controlling on a wide convex surface the surplus water that at present does no very serious damage though concentrated in a narrow concave valley.

Roads provided with emergency outlets at any convenient intervals could eventually be run along the lower faces of the series of *bandhs*.

When it was desired to increase the capacity of the tanks, the earth excavated, if not required for raising the *bandh*, could be distributed over a strip of the upland above the tank so as to level it and raise it to a higher level above the water. These strips with water at a high level in the sub-soil at the end of the monsoon, and well drained, would be valuable for cold weather crops.

The general control of the rainfall of Chota Nagpur, in detail, in this way, would bring within reach the possibility of utilizing some of the power that is now wasted in the uncontrolled rush of water from an average height of 2,000 feet on the plateaus to sea-level. Supposing that half of the 45 inches of monsoon rainfall evaporates or is transpired by vegetation, and remembering that the whole of what soaks into the surface re-appears on the surface a few feet lower down, and supposing that only 500 feet of the total fall could be used effectively, the power retrievable from the Ranchi District alone would average over $1\frac{1}{4}$ million horse-power for six months of the year.

THE IMPORTANCE OF THE DEVELOPMENT OF THE DAIRY INDUSTRY IN INDIA.*

BY

W. SMITH,

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THE broad problem lying at the root of progress in India may be said to be the increase of the wealth-earning power of the masses and the ensuring of the benefits of this increased wealth to those who earn it, or, in other words, the increase in the wealth-producing capacity of the man in the field, and the prevention of the grabbing of this increase by parasitical classes who do not help to earn it. India is mainly an agricultural country, and to advance its real prosperity not only must the wealth-earning capacity of the cultivator be increased, but the productive capacity of the soil must be enlarged and the agricultural resources of the country developed. I know of no sphere of agricultural development which offers such a promising field in this direction as the development of the great dairying industry, because, as I hope to show later, the progress or otherwise of this industry very seriously affects the greatest of all agricultural problems in this country—the cattle-breeding problem. The wisest of Eastern monarchs has left it on record that "much increase is due to the strength of the ox", and this three-thousand-year-old maxim may be taken as doubly applicable to India to-day. Every agricultural operation in this country, right up to and including the transport of produce to the rail, is dependant on the strength of the ox, and it follows that every addition we can make to the strength and efficiency of this animal is a direct increase to the wealth of the country, and, if we can eliminate the money-lender, a

* A paper read at the Sixth Indian Science Congress, Bombay, January, 1919.

corresponding advance in the standard of living of the man who owns and works the ox.

It is my opinion, based on thirteen years' close contact with cattle-breeding in all parts of this country, that the strength of the ox is decreasing in India, and that the country to-day does not breed the same quality of milk and draught stock it produced twelve to fourteen years ago. This is due to a variety of causes, but principally, I believe, to the conserving of many of the old cattle-breeding jungles as forest reserves, and the spread of the canal irrigation system, thereby converting what were formerly cattle-breeding jungles into grain-producing areas. If this be so, and I think the fact is generally admitted by those who have studied the subject, then there is only one remedy, which every other country has had to adopt when it met a like problem, *viz.*, the cattle must be bred on the cultivated lands. This can only be done and will only be done when it is economically sound for the cultivator to breed and rear cattle, and it is in order to make the breeding of cattle a payable proposition that the dairy industry must be developed.

I have heard it stated by those in authority in India that you cannot produce a good class of draught bullock out of a first class milch cow. My experience does not confirm this; rather I maintain that you cannot possibly produce the very best class of draught bullock out of anything but a really good milking cow. The ability to produce milk, Nature's all suitable food for the young, is the strongest and best proof of maternity, and the more efficient and perfect the dam, the more vigorous and healthy the offspring. The quality of yielding milk in no way clashes with draught points, and it can be proved that not only is there no antagonism between first class draught qualities and the giving of milk, but they are identical, and I quote the following well known instances where the very best class of milch cows and draught bullocks are produced from the same stock. In Northern and Central Sweden where most of the agricultural work is done by oxen, the favourite breed is the Ayrshire, and in Southern Sweden where the same procedure is followed, the Holstein is the most popular. These two breeds are probably the finest milk producers in the world to-day and their male stock make most excellent field bullocks. Again the light yellowish brown Swiss cattle of the Jura district are famous as milkers, and their male calves bring very high prices and are specially reared and exported for agricultural work in the vineyards of the Rhone valley. If therefore from the same dam we can produce the best draught cattle of any type required, from the heavy milkers of that particular type, it follows that the primary essential for successful cattle-breeding in India is the development of the dairying industry. To make it economically advantageous for the cultivator or the grazier to breed and rear cattle, they must first obtain and breed from the profitable milch cow. Not only so but given the good milker, the income of the breeder must be assured from both sides, *i.e.*, the technical business part of the dairying industry must be developed so that the cow owner may manufacture and sell to advantage the milk or milk products from his cow, as well as the male progeny which will become the draught animal of the future. It is in connection with the development of the technical and business side of dairying that the most successful results have been obtained in the application of co-operative methods to productive agriculture. In most countries of the world which have a peasantry who cultivate their own lands, the manufacturing and distributing side of the dairy industry is done on co-operative lines, and the result has been that not only do the small cow owners reap the whole of the benefits of their industry, but the educative and moral effect of co-operative association in this class of business has been of great value in teaching the small farmers business methods, the value of combination, and in time eliminating the usurer. I know of no reason why the same results should not follow the development of co-operative dairying in India, and if by means of co-operative dairying the Sowcar or Gombeen man of the East can be eliminated and the actual producer get the great part of the fruits of his labour, this is in itself a strong reason for the necessity of the advancement of the industry in India.

As things are now in many cases, the cow is useless for anything but dropping a male calf, and as it may be assumed that half of the animals born yearly will be males and half females, the greater part the female stock born are an incubus on the land and in breed-; parlance " eat their heads off." In short, as cattle-breeding in dia must in the future be done by the cultivator it cannot be made ally profitable outside of the dual purpose cow, producing milk in e case of the female and efficient draught qualities in the case of e male. No other system is practicable, as heifers not required r breeding cannot be sold for beef in India, nor can they in many ses be killed off as useless. In districts where male buffaloes are itable for draught the same argument applies.

Every agricultural operation in India depends to some extent 1 the efficiency of the draught ox. This efficiency can only be creased and secured by the development and the fostering of reeding on dual purpose lines, *i.e.*, dairying and draught. From is point of view the development of dairying in India is of aramount importance, but there are other important reasons why e dairy industry in this country must be fostered, and of these I urpose to touch on two only, *viz.*, (1) the necessity for cheap and lentiful supply of dairy produce as a food of the people and (2) the alue of dairying as a means of maintaining the fertility of the soil here general farming is practised.

As regards (1), India is a vegetarian country, the people generally o not eat meat, and I do not think there is anything which can take he place of *ghee* and the various products made from milk, either vaporated or curdled, as wholesome, strengthening and easily assi-milated foods for the people, to say nothing of the absolute necessity or fresh milk for children and aged and infirm persons. The children of the nation are the hope of the future, and in these modern days, when the mother is so often unable to suckle her offspring, a cheap, pure and plentiful milk supply will go a long way to reduce the heavy infant mortality in cities and large villages. At the present time in most large cities and many Indian villages, pure milk is a luxury of the rich whereas it ought to be the common food of the poor, and from the point of view of the health of the people at large and their food supply generally, the importance of the develop-ment of the dairying industry in India cannot be overstated. There is no nation in the world whose people appreciate the product of the cow so much as the people of India and yet to-day Indian cows generally are 100 per cent. less efficient as milk producers than those of most civilized countries. That they can in time be made more efficient is a certainty, and it is a truism that the efficiency of the dairy cows of any country is a true indication of the general agricultural advancement of that country.

As regards (2), the problem in front of the agriculturist in India, especially in the irrigated areas where failure of rainfall does not enforce frequent fallow years, is how to best restore the nitrogen, potash, and phosphates to the soil which the crops have removed, and there is no doubt that the development of dairying amongst the cultivators would, to a large extent, solve this problem. The land suffers in India from the want of what may be classed as mixed farming, and until the man who tills the soil gets into the habit of rearing and keeping cattle on his land, which can only be profitably done on dairying lines, there is no hope of his adequately manuring the land. If every cultivator fed a large part of the fodder grown on his land and a small part of the grain he produced, to cattle housed on the land, the manure from the cattle, if carefully husbanded and scientifically applied, would greatly enhance the general richness of the soil and increase its productive capacity. It may be said here that the practice of burning manure so common in India would prevent this, but this factor also can only be altered on economic lines, and I believe that the introduction of general dairying would go a long way to prove to the cultivator that the value of cowdung as a manure was in many cases greater than its fuel value, and in any case it would increase the quantity available so that an appreciable quantity would be left for manure after meeting fuel requirements.

To sum up, from an agricultural point of view the development of the dairy industry in India is of the greatest importance because—

(1) only by this means can the greatest of all agricultural problems in India, the cattle-breeding problem, be placed on a sound economic basis;

(2) it particularly tends itself to development on co-operative lines; agricultural co-operation has been the business

salvation of the small holder in many countries and it should be so in India ;

(3) the solving of the cattle-breeding problem on dairying lines must at the same time enormously increase the productivity of the land as the farmer will breed, rear and feed his own animal on his own land, and their manure will be available to renew the fertility of the soil year by year.

From a general point of view, as apart from the purely agri-ltural aspect of the question, there remains the great and far-aching effect of the development of this industry on the health the common people. Cheap and pure dairy produce is essential the health of the community, they cannot get it now, and nothing t the development of dairying as a national industry will give to them.

A DISEASE OF THE PARA RUBBER TREE CAUSE[D] BY *PHYTOPHTHORA MEADII*, McR.

BY

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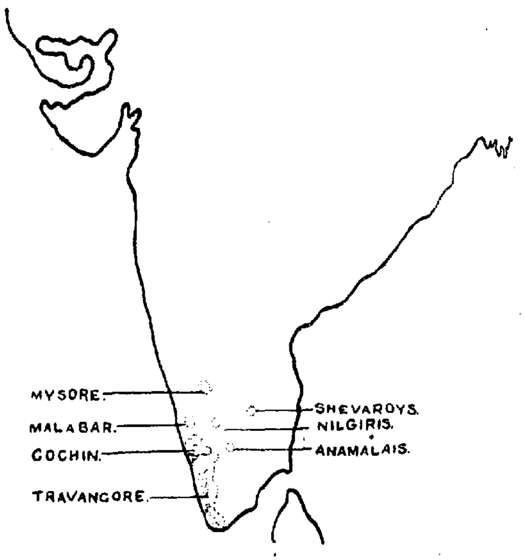
In India the Para rubber tree, *Hevea brasiliensis*, is grow chiefly in the south-western region of the peninsula along the oute fringe of the Western Ghats from the southern part of Travanco through Cochin State to the northern part of the district of Malaba as well as in a few more inland localities in the Anamalai, Nilgi and Shevaroy Hills, in Coorg and in North Mysore where it is grow



Map showing the position of the rubber-growing area.

at higher elevation in a climate not usually considered particularly favourable. The estates occupy the flat land in the upper parts of the valleys and the lower slopes of the foot-hills, and individual estates or groups of estates are separated from one another by vast stretches of forest and jungle. The area of these blocks of *Hevea* grown as a pure crop varies from 100 acres or so up to 10,000 acres. Leaving out two small groups of trees planted experimentally by the Forest Department about 1879 and 1886 and single trees and groups of half a dozen in compounds and gardens, the first *Hevea* was planted under estate conditions in 1903, and during recent years it has been planted rapidly and now there are about 60,000 acres of which over half is in full bearing.

RAINFALL.

The annual rainfall in this area is always high, being about 120 to 140 inches on most estates while reaching as much as 240 inches on some, and about two-thirds of this comes during the months from June to September. The south-west monsoon usually bursts early in June, after which it rains more or less continuously for the next three months. During October and November a fair amount of rain falls under the influence of the returning north-east monsoon, the precipitation occurring as heavy showers. From December to March there is little rain and the weather is comparatively dry and hot, whilst during April and May there are occasional showers which are connected with cyclonic disturbances. On the whole, then, the climate is warm and moist with the exception of a spell of hot weather when the humidity is comparatively low. Thus the conditions are eminently suitable for the growth of the fungus that causes the disease which is the subject of this note.

EARLY NOTICE OF THE DISEASE.

During the increased activity of planting in 1909-1910, while the planters were trying to meet the large demand partly from the older estates, their attention was directed to the fact that considerable numbers of fruits were rotten on the trees. Then too it was noted that there was some shedding of leaves during the monsoon in addition to the normal leaf-fall that took place in the dry weather. When the demand for seed subsided, however, less attention was paid to these two phenomena. Again about 1913, when efforts were being made to utilize rubber seeds for the extraction of oil, attention was directed to the fruit-rot. Still as the demand for seed for planting had become small compared to the available supply and the utilization of the seed for other purposes was a minor matter, the disease was not thought of much consequence. The falling of leaves during the monsoon was by most people thought to be a natural phenomenon correlated with the wet conditions of a heavy monsoon. As, however, rubber yields did not go up so rapidly as was expected, this abnormal shedding of the leaves in the monsoon was investigated as a possible cause.

Periodic leaf-fall.

When young, *Hevea* does not shed its leaves periodically, so that up to the fourth or fifth year the trees are ever-green. Subsequently the normal season of leaf-fall on the West Coast is December to January. At some period during that time most of the trees are bare, but some retain a considerable proportion of the old leaves till the new flush is well expanded, and some trees are flushing while others are still shedding leaves. The leaves assume various tints of yellow, brown and red before they fall.

Abnormal leaf-fall.

A second and abnormal leaf-fall occurs on infected estates during the monsoon. Towards the end of June when the monsoon has set in steadily, trees begin to shed their leaves and continue to do so in ever-increasing numbers till about the middle of August or even later if the monsoon is late, after which leaf-shedding becomes inappreciable. Some trees lose all their leaves and stand quite bare but some lose only a portion. (Plate XVII, fig. 4.) Many, however, do not shed them to any appreciable extent, and these are invariably trees that have few or no fruits. By August the foliage looks decidedly thin and the ground is covered with a thick coating of fallen leaves. On the green leaf-surface there may be dull grey spots or

round or somewhat irregular outline with minute drops of coagulated latex towards the interior. (Plate XVII. fig. 2.) The stalk of the leaf or of a leaflet may have a dark brown spot which in well marked cases is slightly sunk below the general level of the surface and has drops of coagulated latex. (Plate XVII, fig. 2.) Leaves sometimes assume shades of yellow and red before they fall as happens during the normal leaf-fall in December-January, but quite a considerable number come down green with no discoloration on the leaf-surface or on the stalk. After this second leaf-fall a certain amount of new flush is produced, but badly attacked trees stand bare till the natural periodic renewal of leaves in January.

Some trees in the tropics shed their leaves normally several times during the year. Among others Schimper[1] mentions that, in the botanic gardens at Buitenzorg, *Urostigma glabellum*, a gigantic tree, sheds its leaves and produces new foliage about every two months. No records of this kind, so far as I am aware, have been published for trees in South India. There is, however, an impression that *Terminalia catappa*, to mention one only, sheds its leaves twice during the year. Mr. R. D. Anstead, to confirm this impression, kept a record last year in Bangalore and found that leaf-fall occurred in February and October and both periods of leaf-fall were followed immediately by the production of blossom. Trees that usually have only one period of leaf-fall, sometimes in dry seasons, have a second more or less complete leaf-fall. *Melia Azadiracta* in Coimbatore generally sheds its leaves once a year in March and flowers in April, but in 1918, a year of prolonged drought, it shed its leaves a second time in September and flowered about the end of that month. Though blossom often follows leaf-fall this is not always so; for example, in the case mentioned above by Schimper. In the case of the second leaf-fall of *Hevea* no period of flowering follows: it is not a general phenomenon over all estates but is confined to particular areas and varies in amount from year to year on the same block of trees. It does not occur in Burma and the Straits, and in Ceylon occurs as it does in India. It seems more likely to be due

[1] Schimper A. W. F. *Plant Geography*, Eng. Tran., 1903, page 245.

to a local influence affecting individual trees, than to an outward or an internal cause connected with periodicity in the leaf-fall. A fungus, *Phytophthora Meadii*, was found to be constantly associated with trees that had the second leaf-fall and was shown to be able to cause leaves to fall from shoots that it had invaded.

Besides occurring on leaves and causing them to fall, this *Phytophthora* also causes a fruit-rot, a rotting of the bark near the tapping cut, and a partial die-back of the branches.

Fruit-rot.

About three weeks after the monsoon rains have set in, dull ashy-grey spots appear on the fruits of infected trees and gradually increase in size till they cover the whole fruit. The outer pulp becomes soft and rotten. The " shell " does not split and the seeds become discoloured and rotten. (Plate XVII, fig. 1.) The surface of the spots, especially during a break in the rains, becomes covered with a thin incrustation which is white when dry and consists of mycelium of *Phytophthora* with a most copious formation of sporangia. In badly infected areas every fruit on a tree may be rotten and over whole blocks of trees it may hardly be possible to get more than a few sound fruits.

Die-back.

After the leaves have fallen from infected branches, the latter die-back from the tip to a greater or less extent, and at the junction of dead and living tissues the mycelium remains alive during the hot dry season from December to March when the fungus is not active on any part of the tree. When the early rains come, the fungus in this position invades new shoots that arise from the branch immediately behind and causes them to wilt. It gets on to the leaves and causes them to shrivel (Plate XVII, fig. 3), and forms on their surface many sporangia, the zoospores of which get to other shoots and leaves.

Bark-rot.

During the heaviest part of the monsoon when the trees are continuously wet, a rot appears in the vicinity of the tapping cut.

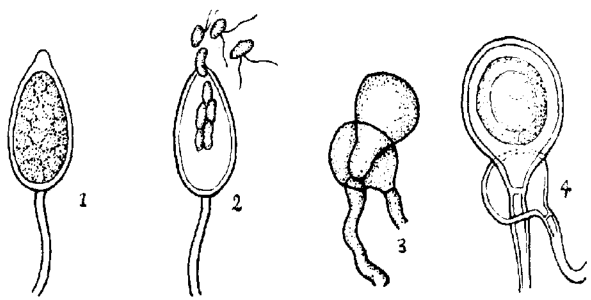
Dark spots appear and extend upwards on the recently tapped bark for an inch or two in dark streaks, the underlying tissue becoming soft and sodden, and exudations of latex appear on the surface as well as in cracks in the tissue, forming sometimes large pads between the bark and the wood. If no break occurs in the rains and if tapping is not stopped, the bark splits vertically along the lines down to the wood, then laterally, exposing the wood sometimes throughout the length of the tapping cut. The bark gradually rots away leaving an exposed area of wood sometimes 17 inches long by 1 to 4 inches broad. In some years when the rains are not so continuous and when tapping is stopped at once, bark-rot though present does not penetrate so far and the wounds heal over fairly quickly after the rains have stopped.

Second leaf-fall usually occurs first on *Hevea* when the trees come into the fruiting stage which in South India is usually about the fifth year. Then, however, it is the fruit-rot that is most in evidence, while in succeeding years the second leaf-fall becomes more noticeable. Younger *Hevea* does not have such a leaf-fall in the monsoon though it has been seen on individual trees or groups of trees where such have been planted among older trees or occur as supplies. Bark-rot may occur in the first season in which the fruit-rot appears or in a subsequent season, but it has not been seen on blocks that have not had fruit-rot. The disease began in the southern part of the *Hevea*-growing area and gradually extended till now few estates have escaped loss to some extent.

THE FUNGUS.

Phytophthora Meadii is found in all the tissues of the parts already mentioned. The hyphæ ramify chiefly between the cells and either come to the surface to produce their sporangia or produce sexual cells inside the tissue of the fruits.

The sporangia are minute pear-shaped sacks containing usually from 14 to 22 spores. When one is ripe, the apex dissolves in the presence of water leaving a hole through which the spores escape. Each has two cilia which lash to and fro and cause the spore to move in the drops of water. They are produced in enormous numbers, especially on leaves and fruits. The sexual spores are particularly interesting for the fact that the oogonium (female element) grows through the antheridium (male element). They have thus the same relative positions as Pethybridge found in *Phytophthora*



1. Ripe sporangium. 2. Motile spores escaping. 3. Young antheridium and oogonium. 4. Mature antheridium, oogonium, and oospore.

erythroseptica on *Solanum tuberosum* (potato) and Dastur in *Phytophthora parasitica* on *Ricinus communis* (castor). The oospore is thick-walled and the protoplasmic contents are dense, and it has probably the rôle of a resting spore.

The fungus has been brought into culture on various media, *e.g.*, French-bean-agar and Quaker-oats-agar, and these cultures have been used with success to cause the various phenomena on leaves, branches, fruit and bark. Put on *Ricinus communis* (castor) and on *Manihot glaziovii* (Ceara rubber) the fungus attacks the leaves and stems though it has not been found on these two plants in Nature. Put on fruits of *Theobroma Cacao* (cocoa plant) it causes a fruit-rot somewhat like the fruit-rot caused by *Phytophthora Faberi* in countries where cacao is grown as an economic crop. Careful comparative tests were made with these two fungi on cacao and *Hevea* fruits, and it was found that *P. Faberi* and *P. Meadii* readily infected *Hevea* fruits while cacao fruits were readily infected by the former but with difficulty by the latter.

Dissemination.

The fungus appears to start its activity after the dry season at comparatively few points, but when the monsoon has once burst it spreads rapidly. Sporangia are produced on the surface of the fruits in very large numbers indeed, and the zoospores in correspondingly greater numbers. The rapid dissemination from the first few infected fruits can be explained by rain-drops that fall on these infected fruits splashing the spores considerable distances to other fruits. Faulwetter[1] showed by experiment that water is splashed by a falling drop only when it falls upon a film of water, and it is the water of the film which composes the splash drops. A drop 0·2 millimetre falling 16 feet on to a horizontal glass slide covered with a film of water splashed drops to 24 inches. In wind driven by an electric fan and travelling at ten miles an hour at the point of splash which was three feet above the floor, a drop falling 16 feet splashed drops to extreme distance of 18 feet. The size of the drops is comparable to that of rain-drops and winds of ten miles an hour, and much more during the early part of the monsoon are often experienced on rubber estates. With the almost continuous rain the opportunity of continuous distribution by splashing is given, and even though frequent collisions between splash-drops and rain-drops will occur, thus preventing many of the former from reaching their extreme distance, still some of them will be carried off and be again splashed farther distances. This explanation would seem to be sufficient to account for the rapid spread of the fungus from fruit to fruit and to leaves on an estate, and the great number of motile spores produced on infected fruits provides many opportunities of their being washed down on the tapping surface.

Loss.

Hevea has been attacked by this fungus in South India before planting has been well established, so that there is no very extensive series of figures showing the yield of latex for any length of time on the estates of healthy trees. Estates have been in bearing for only a few years, 8 or 10 at the most, and that on a comparatively small acreage which has gradually become affected by abnormal leaf-fall. It is thus difficult to estimate the latex yields that might normally

[1] Faulwetter, R. C. "Wind-blown Rain, a factor in Disease Dissemination." *Journ. Agric. Res.*, X, pp. 639–648, 1917.

be expected. That so far they have not come up to the expectation current at the time of planting is fairly generally conceded, and part of the shortage is undoubtedly due to the effects on the trees of *Phytophthora*. The loss due to the rotting of fruits is a minor factor, as the utilization of fruits for purposes other than planting, for the present at any rate, hardly comes into the estimate. From discussions with most of the planters who have had much to do with the disease, I have come to the conclusion that 30 to 40 lb. of made rubber per acre per annum is about the average loss and it may be as high as 70 or 80 on badly infected blocks of trees. This transposed into money value, with the rubber, say, at 2*s*. 9*d*. per pound and the cost of production, say, at 9 pence a pound, gives a loss of from £3 to £4 per acre per annum, which multiplied by the yielding infected area of about 30,000 acres represents a total loss to the industry of about £100,000 sterling and a possible future loss over the area of 60,000 acres of a very large sum of money indeed. The loss involved is so large that it is practicable to spend a large sum of money on preventive measures on every estate.

Preventive measures.

In considering preventive measures the main facts to be borne in mind are (1) that the mycelium passes the dry weather inside branches that have partially died back, (2) that oospores, which are resting spores, are found in the fruit, and (3) that the fruits are the main propagating centres for multiplying the fungus. This suggests that the branches that have died back and the fruits should be dealt with. In the one case the aim is to stop the fungus from beginning its activity in the new season, and in the other to stop its rapid propagation after it has once begun. If all branches that this fungus has caused to die back were removed, say, a foot beyond the junction of living and dead tissues, many of the centres of infection that begin the new attack of the fungus each year would be destroyed. Now all branches that die back on *Hevea* do not do so because of this fungus. There are other factors that produce die-back, *e.g.*, shade causes the lower branches to die and other fungi also do so. There is no simple field method of distinguishing between these various causes, that, if die-back branches are to be removed, then all will have be removed irrespective of the causative agent. Many of the branches that have died back are mere twigs while others are larger. There are many such on each tree—far more than is realized till the necessity comes to remove them—and they are scattered over the tree indiscriminately; however it is quite possible to remove them to a very large extent.

It has been shown that the fungus may invade a branch along the fruit-stalk, and that the fruit-stalks of rotted fruits may remain on the tree through the dry weather till the beginning of the monsoon. This is a real difficulty in the way of preventive measures, for it is impossible to remove every possible centre of infection of this kind. If all these old fruit-stalks were removed when the trees are bare in December-January, there is the fact that the mycelium of the fungus invades the branch from which the fruit-stalks spring at their point of insertion. Removing die-back branches would not destroy this source of re-infection entirely.

Removal of the fruits before the break of the monsoon would stop the rapid propagation of the fungus that begins about 15 days after the monsoon has set in. This would also for future infection get over the difficulty mentioned in last paragraph with regard to infection by fruit-stalks. If the fruits are not there to become infected the fruit-stalk would not carry the mycelium of the fungus into the branches.

There is another possibility, *i.e.*, the destruction of the flowers in order to prevent the formation of fruit. This could be done by cutting off the flowers or by spraying them with a chemical that would kill them. It has been found that only about 35 per cent. of the inflorescences bear mature fruit, that the stalk of the inflorescence is so pliable that it bends before the knife unless it has almost a razor edge, and that many leaves are removed with the inflorescences. These three drawbacks render this method impracticable. A solution of copper sulphate does kill the flowers, but spraying is impracticable because of the lack of water in the flowering season and, since the inflorescences are scattered over the whole tree, so much of the solution has to be used in order to get at each flower that it practically means spraying the whole tree. The same applies in a increased degree to spraying the fruits in order to prevent the fung developing on them as the stand of foliage is greater during th fruiting season.

The question whether it is not possible to prevent trees fro flowering or to reduce the amount of flowering by some cultur means has also been considered, but it does not seem feasib Horticultural endeavour has been rather in the direction of increasing the flowering capacity of plants, and so far as we know there are n cultural methods of preventing a tree from flowering or reducing the number of flowers it produces that are applicable in estat conditions.

In a block of 100 acres dead branches and fruits were remove during two successive seasons. An adjacent block of about th same size was taken as a check. In 1917 the contrast between th amount of second leaf-fall was very marked. While the che blocks had a heavy fall of leaves, the treated block had hard any. One tree in the treated block, inadvertently omitted duri the operations, shed nearly all its leaves and had fruit-rot, and an adjacent tree shed the leaves on the side next it. Bark-rot though present was very much less on the treated block. The operations were very carefully carried out and the total cost was Rs. 19-1 per acre. In 1918 the monsoon was scanty and the disease was no so severe as usual. Still the contrast was distinct and in favour o the treated block. In 1918, from another block of 70 acres th dead branches only were removed and the result was satisfactory It requires a more normal monsoon, however, to decide wheth this treatment alone is enough. If it is, it will be more economic as the removal of the branches costs about one-third of the tot cost. The drawback of this method is that a large labour force required at the time when the coolies usually go to their homes the low country. If the method stands the test of further seaso then its application becomes a matter of business organization.

Meantime efforts are being concentrated on the prevention bark-rot. The method that has become most general is to pa with a chemical, usually one of the products of coal-tar distillati tapped surface of the bark that is to renew. Izal and a mixture tar and tallow are the two most employed though others are used cording to availability. Greater attention is also being paid to ting a clearer air space around the trunks and to keeping the tate in a clean condition.

THE COFFEE PLANTING INDUSTRY IN SOUTHERN INDIA.

BY

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THE history of the introduction of the coffee plant into India has been given in an article already published in this Journal.[1]

Tradition has it that this crop was first introduced about tw centuries ago by a Mahomedan pilgrim named Baba Budan, wh planted it on the hills which bear his name in the Mysore State The first systematic plantation in Mysore appears to have bee established in 1830 near Chickmaglur, and about this time planta tions were also established in the Wynaad and on the Shevaro Hills. By 1846 it had spread to the Nilgiris. In Mysore the oldest existing coffee was planted between 1830 and 1841, while a number of estates were opened from 1870 to 1880.

For the following account of the early history of coffee in Coorg I am indebted to the kindness of the late Commissioner Mr. F. Hannyngton.

"The suitability of the soil for coffee cultivation appears t have attracted the attention of the European planter about th year 1882. The capabilities of the province as a coffee-growin country had long before been known to the natives, and it is a matte of surprise that European enterprise did not enter on the field t a much later date. It is conjectured that, during the time of th Coorg Rajas, some Moplas, who had obtained grants of land ne Nalknad introduced the shrub from seed which was brought fro

[1] *The Agric. Journ. of India,* vol. XII, pt. III, p. 413.

ocha' or perhaps second-hand from Manjarabad. Its successful d profitable cultivation was at first concealed from the Coorgs, t these were shrewd enough to find out for themselves that, whilst ne of the fabled fatal consequences followed the cultivation of e shrub, there was a ready and lucrative sale for the produce. rough the exertions of the first Superintendent, Captain Le ardy (1834-1843), who took a deep interest in the material pros- erity of the country, the coffee plant became almost universal.

"When coffee cultivation was taken in hand by European kill and energy the industry soon assumed greater importance. Ir. Fowler, the first European planter, opened up the Mercara state in 1854, Mr. Mann became the pioneer on the Sampaji Ghat 1855. Dr. Maxwell opened up the Periambadi Ghat estates in 1856, nd in 1857 Mr. Kaundinya founded Anandapur village with a most romising plantation in the bamboo district. Round these first ntres of cultivation, dozens of extensive estates gradually sprang up.

"The year 1883 marks the commencement of the decline of ffee, when the price fell by forty per cent., a result due chiefly to 1 over-stocked market and the competition of Brazil. The low prices fetched during the following few years dealt the death-blow to many Indian estates, the owners of which were dependent on loans from *sowcars* whose high rates of interest they were no longer able to pay; they were therefore unable to raise the funds to meet their working expenses and the estates rapidly deteriorated. A few years' neglect in a coffee estate is sufficient to ruin it, and the all in prices therefore resulted in the disappearance of many once lourishing estates, nor could the exceptionally high prices sub- equently obtained avail to redeem the misfortunes of the past. he estates on the Ghats which were opened without shade were now beginning to show signs of irretrievable decline; in 1889 several large European estates on the Sampaji Ghat were relinquished wholly or partially, and a few years afterwards the estates on the Periambadi Ghat were resigned to Government. By 1898 all coffee on the Ghats had practically disappeared."

Another factor which played a part in the reduction of the acreage under coffee was disease, especially leaf disease, caused by the fungus *Hemileia vastatrix*, and root diseases. The latter are associated with the decaying stumps of jungle and other trees. As the coffee began to decline and leaf disease to appear, many planters thought that they were growing the wrong kind of shade and proceeded to change it by cutting out large numbers of certain kinds of trees especially *Acrocarpus fraxinifolius*, without taking any precautions whatever about the stumps, which, as they rotted, afforded a suitable habitat to root-disease-producing fungi. These rapidly spread to the coffee and killed large areas of it, and in some parts of Mysore one now sees tracts of land returned to grass and scrub which were once flourishing coffee estates.

There is, however, a more cheerful side to the picture; many of the best estates weathered the storm and with the improving situation the area of these was increased. The total distribution of the coffee acreage in South India at the present time is as follows:—

	Acres
Madras Presidency	48,4[illegible]
Coorg	42,6[illegible]
Mysore State	12[illegible]
Travancore State	7,[illegible]
Cochin State	2,[illegible]
Total	223,[illegible]

As will be seen, the chief coffee-growing areas are Mysore and Coorg which contain 74 per cent. of the total. In these districts the acreage is approximately divided as follows:—

COORG.

	Acres
Area under cultivation by Indians on European lines	17,[illegible]9
Area under cultivation by Indians on native lines	3,6[illegible]5
Area under cultivation by Europeans	21,22[illegible]

MYSORE.

Area under cultivation by Indians	101,255
Area under cultivation by Europeans	21,265

During the last 15–20 years much more attention has been paid to the scientific cultivation of coffee under the guidance of Dr. Lehmann and others, and with the establishment of the Scientific Department of the United Planters' Association of Southern India in 1909, the control of diseases and systematic manurial schemes have been widely adopted. Much remains still to be done and learned, but some of the more marked advances may be mentioned.

The study of the mechanical and chemical composition of the coffee soils in relation to the manures required has received attention. South Indian coffee soils are markedly deficient in calcium oxide and available phosphoric acid. The shade, under which the coffee must be grown to protect it from the sun and drying winds in the hot weather, produces conditions rapidly leading to acidity of the soil. The falling leaves make a valuable mulch covering the ground several inches deep, and as this rots down acidity may be set up. Consequently frequent applications of lime are found to be beneficial, the controlling factor being the cost of this treatment. Unfortunately, there are few coffee estates situated near good deposits of limestone and most of this material has to be transported from the coast in the form of burnt shells, and this is expensive. In Coorg, trials are now being made of finely crushed limestone obtained in Hunsur some thirty miles away. Applications of soluble and basic phosphatic manures like basic superphosphate and basic slag have also proved beneficial. For many years it was the custom to apply to the coffee nothing but a mixture of roughly crushed bones and poonac locally obtained with an occasional dressing of fish manure, but now the benefit of varying the manures applied and supplementing them with occasional applications of potash has been realized. A growing number of estates take scientific advice as to manurial programmes based on soil analyses and use a variety of fertilizers, and such systems have proved their value over and over again in increased crop.

Diseases can also be controlled. Root diseases which have done so much damage in the past, are now recognized by planters as due to the attacks of specific fungi, and precautions are taken to deal with them as soon as they occur. The general sanitation of the estates has been improved and stumps of jungle and felled shade trees are removed or isolated. The lines of advance lie in the direction of a careful study of the life-history of the fungi causing these diseases and their exact relation to the decaying stumps of certain trees. Were all the latter known, steps might be taken to mark down their occurrence in new clearings and remove them. In the Nilgiris, for instance, new land is nearly always occupied by secondary jungle and a very common constituent of this is a small tree, *Symplocos spicata*, the decaying roots of which always induce root disease of both tea and coffee, and it has been found profitable to clear the land of the roots and stumps of this tree before planting.

Two important fungi attack the leaves of the coffee, *Hemileia vastatrix* and *Corticium Koleroga*, popularly known as leaf disease and black rot, respectively. The former is wide-spread and found on coffee all over the world, and it is credited with having killed the coffee industry in Ceylon. These diseases can be controlled by spraying the coffee at the right time with Bordeaux mixture or Bordorite, and a good deal of work has been done of late years in this direction. The limiting factors are water and labour. Black rot only occurs on limited areas and thus is comparatively easy to control by spraying, but to control leaf disease successfully very large areas have to be sprayed at one time, and this is a difficult problem. In Nairobi, however, the coffee estates are sprayed throughout two or three times a year, and there is little doubt that the time will come when the South Indian planter will wake up to the fact that spraying is a practical and paying proposition, and power sprayers will be introduced.

Of insect pests one of the most important and deadly is a scale insect, *Coccus viridis*, and a variety of it, *Coccus colemani*. This scale attacked the coffee on the Nilgiris many years ago and nothing was done to check it with the result that it spread to the shade trees, weeds, and general vegetation, and in some districts has killed out the coffee and rendered its cultivation unprofitable. Luckily in this part of India coffee could be replaced by tea. In Mysore and Coorg, however, coffee is difficult to replace by any other crop, and when the scale appeared in these districts in 1913 something like a panic occurred. It was found, however, that the scale could be controlled by prompt spraying with an insecticide, like fish oil resin soap, while in the monsoon it was attacked and naturally controlled by two fungi, *Cephalosporium lecanii* and *Empusa lecanii* which also works in the cold weather. Steps were taken to teach the planter the best methods of control, spraying in the dry weather, and spreading the fungus by contact, that is, by introducing branches containing fungus-attacked scales and tying them into the trees where the fungus did not occur naturally, in the wet weather, and the pest has been successfully kept in bounds, and it now does only real damage in years which particularly favour it. It was also found that certain species of ants common on coffee estates, more especially *Cremastogaster*, play a large part in the distribution of the scale, and if their nests are energetically destroyed the attack can be largely controlled.

In Coorg, another insect pest which does a considerable amount of damage is a scale insect, *Dactylopius citri*, which attacks the roots of the coffee, especially young plants. So bad is this pest in places that it was found impossible to raise young clearings. Lefroy first studied this pest and recommended certain measures for its control. Recently a cure has been found in apterite, a soil-disinfectant used in England, consisting of naphthalene and crude carbolic acid. This has been used with great success to protect the young plants till they get big enough to resist the attack of the scale. Since the war it has been impossible to import this material and stocks were soon exhausted. It is now being manufactured in the Madras Presidency, and after the war it is possible that it will be found cheaper to make it than import it.

Other pests and diseases have been controlled, and at the present time the coffee planters are fully alive to their importance and understand their causes. Much remains still to be done, however, in the study of the life-history of diseases, especially those caused by fungi, but a considerable advance has been made.

The coffee on many of the estates is very old, in some cases individual trees must exist that are 60-70 years old whilst on estates like Balmadies, in the Shevaroy Hills, some of the coffee is over 90 years of age. The time is coming when this old coffee will have to be replaced. During the history of the coffee industry one big change has already taken place, when the old "Chick" coffee was replaced wholesale with the more vigorous and robust Coorg strain. There seems to have been little difficulty in making this change but on the old estates now it is not easy to raise young plants or to grow supplies, and old coffee land is notoriously difficult to replant. This is due to a number of causes which need not be gone into here. One of the reasons for failure, however, is that the strain of coffee now grown has been allowed to deteriorate. No care has been taken in selecting seed from which to raise nurseries. One of the most important advances in recent years has been the realization of the necessity for better seed selection, and the possibility of raising a new, vigorous strain of coffee by means of hybridization along Mendelian lines. This subject has been dealt with in an article reproduced in another part of this Journal. The matter has been taken up by a few of the more farseeing planters, and a hybrid exists which has all the vigour of the old Coorg, is highly disease-resistant, and which bears very heavily, much more heavily than the ordinary *arabica* type now cultivated on the estates in general. This is now being grown on an estate scale and a great future lies before it. In fact the future of coffee in South India undoubtedly lies in two main directions, first the raising of good hybrid strains which will bear more heavily than the present coffee and the replacement of the old worn-out estates with these and, secondly, in a combination or co-operative society of coffee planters to control the local coffee markets and prices and to develop and organize the local sales of Indian-grown coffee, as well as to do their own curing. Progress is slow and it is difficult to overcome deep-rooted customs and prejudices, but there are ample signs of a new era in this direction.

By far the majority of the coffee grown in South India is of the *arabica* variety. Of recent years a certain amount of *robusta* coffee has been planted; and this variety is in growing favour on poor soils and as a catch-crop among *Hevea* rubber. It bears heavily but produces an inferior grade of bean, but it will no doubt find a place as a subsidiary crop in many places.

Recent advances have also been made in the machinery employed on the estates to prepare the coffee for market. In old days bullock power was used for driving the pulper, now the majority of estates are equipped with oil engines and modern pulpers and well-laid-out arrangements for washing the coffee. On one estate a further advance has been made in the instalment of a dryer in which the washed parchment coffee is dried by means of hot air in a revolving drum. This hastens the process as compared with the usual sun drying and renders the process independent of weather. Moreover, it improves the colour of the coffee and results in a great saving of labour. The final curing of the coffee is done by curing firms at the coast where a hot sun is available. Here again there is room for improvement, and development lies along the line of co-operative bodies of coffee planters owning their own curing works to which the coffee will be sent from the estates comparatively dry from artificial dryers. In this way the curing of the crop will be hastened and shipment take place well ahead of the monsoon.

With regard to the future development of the coffee industry, several lines have already been indicated. It remains to say that the Scientific Department of the United Planters' Association of Southern India is about to be reorganized and enlarged. It will be controlled by the Madras Agricultural Department under the Director of Agriculture. A coffee experiment station is being established in Coorg on the lines of a Government farm, where a whole series of experiments will be undertaken to study manuring problems, cultivation methods and disease control, and possibly in the future plant-breeding problems. It is also proposed to add to the staff a Planting Mycologist recruited from Europe who will take up among other things the study of the many fungi which attack coffee.

There are a certain number of people who have never happened to visit a good coffee-growing district, who are apt to think that coffee planting is a decadent industry, but this is by no means the case. It is a very flourishing concern and its outlook on the future is a bright one. The demand for high grade coffee in the European market is always likely to exist, and it is just these high grade marks which South India is able to produce and has always produced.

THE "RAJAH" PLOUGH.

BY

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Agricultural Officer, North-West Frontier Province.

On a bright morning, nearly eight years ago, the dry coarse grass on land that now forms part of the Peshawar Agricultural Station was set alight, and before nightfall, with a following breeze, a large part of a block of fifty acres was black in ashes. The jungle consisted chiefly of "dáb" (*Eragrostis cynosuroides*) with some "kahai" (*Saccharum spontaneum*). After irrigation the "Rajah" ploughs were set to work, a plough following in the furrow of each land-plough to ensure tillage to a depth of nine inches. In the following *kharif*, hardly a blade of the grasses appeared; in one brief cold season the "Rajah" completely extirpated the coarsest of root grasses from red loam. The oxen were ordinary animals, the average price of them being Rs. 92-8. And now, after eight years' constant toil with western ploughs, harrows, rollers, cane-mills, etc., most of these good oxen are still in regular work and "going strong," and the "Rajah" ploughs that first turned over the area of 200 acres are still in daily use and sound as when they were purchased in 1910. Without the assistance of the inverting plough the Agricultural Station might still be striving to get rid of tough root grasses. Men and bullocks alike adopted the "Rajah" easily. Almost from the outset they ploughed lands 220 yards long in a manner that would be no discredit to English craftsmen. Hardly ever has the writer seen a Tarnab ploughman leave the stilts to goad his oxen. Plate XVIII, fig. 1 shows that this is unnecessary if the ploughman is provided with a very light, thin, solid bamboo goad, which may rest on the hake of the plough or remain lightly balanced in the hands of the man. Should a ploughman be observed

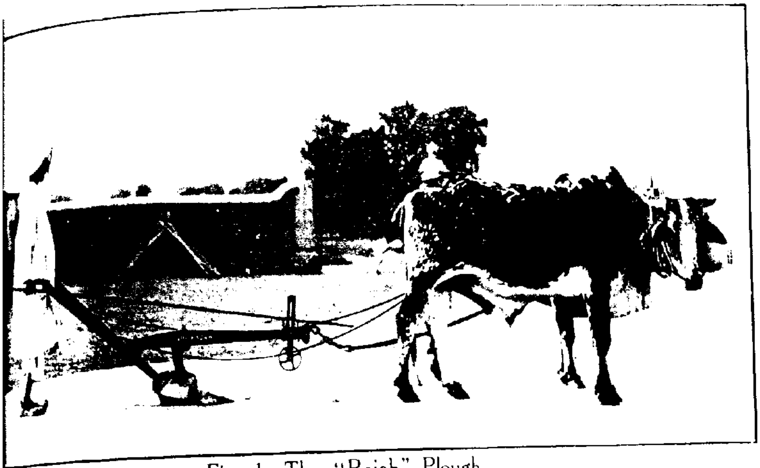

Fig. 1 The "Rajah" Plough.

Fig. 2. Convenient method of carrying the "Rajah"

following on the land without some special reason for doing so, he is liable to be fined at Tarnab, but it has not been necessary to impose a penalty during the past four years. His acre done, the man may unyoke and go home. In many operations besides ploughing the "Rajah" has proved most useful on the farm. It sets up "bunds" on irrigated land; it is employed to make roads and to ensure camber on these; it is sometimes used in earthing up crops, it does most of the work in cutting out watercourses. This all appears satisfactory. The plough, the oxen, the man combine to turn out real good work *on the farm*. It might therefore be expected that the "Rajah" would be appreciated and in daily use by many cultivators, at least in the Peshawar District. But this is not the case. There is not a "Rajah" or other mould-board plough regularly and profitably employed on any cultivator's land in the North-West Frontier Province. And at once it may be stated that it is not the cost of the implement that stands in the way of its adoption by the cultivators. A small unsymmetrical irrigated field can rarely be economically treated by a mould-board plough. With this implement it would not be altogether easy for an English ploughman to leave the land in a level state fit for irrigation. And chiefly for this reason it is feared that for many years to come there is little hope of the cultivators using inverting ploughs on irrigated land in the North-West Frontier Province. After long years of careful dressing, the cultivators' fields are level as level can be. The country plough does not upset the land level; a mould-board plough always does so more or less, and irrigated crops are invariably poor where the land is not level. On unirrigated areas the mould-board plough may sometimes be profitably employed, yet on these lands deep ploughing is usually less necessary than on irrigated fields where rank weeds and grasses are so liable to spring up, and perfect soil-aeration must be assured.

It is on foul, neglected land that the "Rajah" best demonstrates its value to the cultivators, and when an implement is purchased it is usually intended to clean old or to break new land. Those few keen Pathan farmers who have tried the "Rajah" and have sent their ploughmen to Tarnab to be trained in using it, have soon set the steel implement aside and returned to the ploughs of their fathers. Knowing this to be the case no improved Western implement is sent out from the station until the intending purchaser has demonstrated his ability to use it in a workman-like manner.

There is of course no doubt whatever that the inverting plough tills the land far better than, and perhaps just as cheaply as, the country implement. But in the North-West Frontier Province the time has not yet come when even the "Rajah," which has been found so useful at the Agricultural Station, may be generally recommended to the cultivators of small areas. On clean land that has been regularly tilled the country plough is fairly efficient: it does much more than "scratch the soil." Skilfully used, it produces an excellent tilth of moderate depth.

It is sometimes difficult to find, and it is always troublesome and expensive to maintain, numerous yokes of good oxen, and it is just possible that the owners of broad acres may favour light motor-tractor cultivators rather than small mould-board ploughs drawn by bullocks, when they decide to farm part of their land, instead of parcelling it all out to cultivators who have very little capital.

Plate XVIII, fig. 2 shows a good pair of Awankari bullocks taking the "Rajah" to the field in a convenient manner which does not appear to be commonly employed where mould-board ploughs are used.

After this article was written, the writer invited an Indian who has had much experience in using the "Rajah" to say what he thought of the plough's work. "Excuse me, sir, but I hate it," was his reply. Then he explained how the implement kept him in a state of constant anxiety about the land levels. How, in order to make quite sure that the soil could be reduced to mellow tilth when he desired that, it was imperative to roll and level land ploughed by the "Rajah" positively on the day after the furrows were turned. He mentioned how this was frequently impossible and very often difficult and even undesirable, and that in these circumstances the furrowed land could not be levelled until it received rainfall. On the other hand, he held, even when the country plough leaves the land very very "cloddy," the level is not upset, and irrigation and tillage can be done at will.

IRRIGATION TANKS IN THE DISTRICT OF BURDWAN.

BY

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IF the number of irrigation tanks in a tract is any guide to its agricultural prosperity, then the district of Burdwan, especially the central part of it, may be considered to have been, at one time, one of the richest portions of the province of Bengal. Nowhere else can so many tanks be found, scattered here and there all over the fields, throughout the length and breadth of the province. That this district used to be called the granary of West Bengal was due to the fact that the ryots were then fairly independent of the vagaries of the monsoon owing to the use of tanks. These tanks seem to have been dug long ago, and each of them was meant to command an area in proportion to its holding capacity—generally of about ten to twenty acres each—but unfortunately they have been long neglected and allowed to go into disrepair. Many of them have silted up to such an extent as to have been turned into actual paddy-fields, while others do not hold water enough for two or three acres in times of need. Mr. A. C. Sen in his report on the agriculture in the district of Burdwan says: "The great want of the Burdwan District especially of its western and central parts, is a proper supply of water for irrigation purposes. The rainfall being often deficient in total amount, or irregular in distribution, artificial irrigation is necessary for almost all important crops except pulses and barley. In fact, the cultivation of surgarcane, potato, and other important crops can only be undertaken in places where water is available. * * * * * * * * *. In no other part of Bengal are so many tanks to be found but almost without exception they have been long neglected and are now overgrown with weeds and filled up with silt."

In consequence, the present economic condition of the ryots of the district—at least the central part of it which is mainly agricultural with no other industry to speak of—is far from being satisfactory. They are now quite dependent on the distribution of rainfall for their paddy, which is by far the most important harvest of the year in the locality. The cultivation of potato, sugarcane and other profitable cold weather and hot weather crops is now limited to very small areas for want of water-supply. Sugarcane was an important crop in this tract, but now the area under it is going down year by year in spite of the introduction of the superior iron mill and of the rise in the price of *gur*. The cultivation of sugarcane entails much care and labour, and if it fails, or a satisfactory crop is not obtained simply for want of water, the ryots can hardly be blamed for giving it up. Leaving the more profitable crops alone, even when one comes to consider the cultivation of paddy—the mainstay of the cultivator—he sees that the result is largely a matter of chance. Being dependent on rainfall, the ryots try to transplant as large an area as they can within as short a time as possible on the first decided break of the monsoon without having any regard to good tillage ; and they leave the rest to the mercy of the season. If the season is good, they reap a fair harvest and thank their stars. But if the rainfall is scanty, every ryot tries to procure the very little water that can accumulate in these tanks for his own crop, and this leads to bitter quarrels and riots ending in criminal cases in the courts, loss of money and sometimes even imprisonment.

Moreover, this method of cultivation, apart from bringing in its train the effects of bad tillage—and it is well known how serious these effects are—gives rise to another economic evil, namely, breaking up of pasture lands. Under the present state of things, intensive methods of cultivation are out of the question, and extensive cultivation, requiring more land with the increase in population, naturally tempts the ryots to encroach upon pasture lands. So this, among other factors, is largely responsible for the serious shortage of pasture lands and consequent deterioration of cattle in the district. The writer has heard people lamenting that cows do not now give half as much milk as they used to thirty years ago. The reason is not far to seek. Indeed every distress and difficulty of the ryots can be traced back to general poverty, and the writer believes, along with many old ryots of his village, that their poverty can be traced to the long neglected and deplorable condition of the irrigation tanks.

Agriculture cannot prosper in a tract where there is no source of artificial irrigation, as it is absolutely necessary to supplement the rainfall, which is often irregular in distribution, in order to raise a satisfactory crop. The Government of India in their resolution on Land Revenue Policy in the year 1902 remarked "When the produce of the land is liable to great and frequent fluctuations, owing to failure of irrigation or vicissitudes of season, there is reason to apprehend that a fixed assessment may ruin people before it teaches them." But here is a tract where the ryots have become entirely dependent on the vagaries of the season, where they are being reduced, day by day, to the verge of utter destitution; yet they have to pay a fixed rent. The Government are unwilling to interfere because of the Permanent Settlement of Bengal, which has transferred the absolute right in the lands from the State to the hands of the zemindars of Bengal.

These tanks were excavated by zemindars long before the Permanent Settlement, when they had an interest in the lands, as the rent was then a certain portion of the produce—usually payable in kind—and it was an economic loss to them if the cultivators failed to get a full crop out of their lands. Besides, land was then more than sufficient for the population, and the zemindars had some difficulty in disposing of their lands, and as nobody would willingly cultivate lands which had no facility for artificial irrigation, they excavated and used to maintain these tanks. But under the Permanent Settlement the zemindars have practically no concern with their lands; whether the cultivator gets a full crop or not the zemindar gets his rent. So the zemindar takes no interest in the improvement of his lands or in the amelioration of the condition of the ryots. Moreover the real zemindar is now out of touch with the ryots owing to the presence of a series of middlemen—Pattanidars, Dar-pattanidars, Se-pattanidars, etc.—who have very little sympathy for the occupiers. A quotation from the Gazetteer of the district will show how clearly the state of affairs was understood by a high Government official: "The landlords and intermediate tenure-holders have become mere annuitants upon the land, taking but little interest in their nominal estates beyond ensuring the payment of their rent, and practically indifferent to their improvement, or to the condition of the cultivators from whom their income is drawn. Embankments, drainage channels, tanks for irrigation or water-supply, and other works of public utility constructed by the generosity of former landlords, are allowed to fall into disrepair; it is no one's business to repair them: and the landlords have no incitement to undertake any fresh work of improvement, as they can hope for no pecuniary benefit from it." But the zemindars seem to forget that the same Permanent Settlement that bestowed on them an absolute right in their property expected "that the proprietors of land, sensible of the benefits conferred upon them by the public assessment being fixed for ever, would exert themselves in the cultivation of their lands, under the certainty that they will enjoy the fruits of their own good management and industry, and that no demand will ever be made upon them, or their heirs or successors, by the present or any future Government for an augmentation of the public assessment, in consequence of the improvement of their respective estates" (Art. VI, Reg. I of 1793). It is needless to say that, as a rule, these hopes have been falsified.

Now the question may naturally arise why the cultivators do not look after the tanks wherein their vital interest lies? But the fact is that, whereas each tank was meant to command a certain area which was originally leased out to one or two persons, the tank forming a part of the holding (*jama*) or holdings, portions of holdings are always being transferred from hand to hand without reference to the rights in the tanks. At present it is not unusual to find that a tank may belong to a person who may have very little land within its influence; and holdings have been so much divided and subdivided that it is not at all impossible to find fifteen or twenty or more persons having land within the area commanded by a single tank. Now under the present state of things the members of a village community are so poor and so divided into factions that it is extremely hard to get anything done by them. The owners of the lands say why should they go to renovate a tank which belongs to others. And the owners of the tanks say why should they go to renovate a tank the benefit of which would be enjoyed by others. These persons can hardly be expected to co-operate, and even if they were to agree, they cannot do anything for want of capital. A person who is in debt cannot possibly invest money on such works. So there is very little chance of the tanks being renovated by the cultivators unless some system can be devised. But if things are allowed to go on as they are, the tanks will be beyond renovation in the near future, and the agriculture of the locality will suffer an irrevocable loss in consequence.

The writer has been anxiously thinking over the matter for some time, and he has come to the conclusion, after discussing the matter with some of his fellow villagers, that the tanks can be renovated by the cultivators themselves if a scheme, the barest outlines of which are given below, can be framed and worked:

(*a*) Arrangements should be made so that each tank may belong to the different ryots in proportion to the amount of land they hold within the jurisdiction of the tank; that is, the different ryots should have an interest in the tanks proportionate with their holdings. To achieve this, compulsion may be necessary on both the parties—sellers as well as purchasers.

(*b*) The right in the tanks should be automatically transferred with the transfer of land.

(*c*) The owners of the lands commanded by each of the tanks may combine to form a co-operative credit society; so there may be as many societies as there are tanks. And tanks should be renovated from loans taken by these societies.

(*d*) Loans should be given by central co-operative banks or the District Board on their usual terms of business.

(*e*) Two or three tanks should be taken up for renovation every year in every village.

(*f*) Some form of expert supervision should be provided by Government to see that the work is being done properly.

THE FIRST SECTIONAL MEETING OF VETERINARY OFFICERS IN INDIA

THE First Meeting of Veterinary Officers was held in the Veterinary College at Lahore, from the 24th to 26th March, 1919, under the presidency of Mr. J. Mackenna, C.I.E., I.C.S., Agricultural Adviser to the Government of India. Besides representatives from the Veterinary Departments in the different provinces, the Directors of Agriculture, Punjab and the Central Provinces, the Director and the Second Bacteriologist, Imperial Bacteriological Laboratory, Muktesar, the Imperial Pathological Entomologist, the Offg. Imperial Agriculturist, and a representative of the Army Veterinary Corps in the person of Lieut.-Col. W. B. Edwards attended the meeting. Mr. A. W. Shilston, Second Bacteriologist, Muktesar, acted as Secretary.

The proceedings were opened by Mr. Mackenna in a short speech in which he referred to the excellent work done by the Veterinary Service in the great European war, dwelt on the necessity of a large and an early expansion of the Civil Veterinary Department, and eulogized the services of Col. H. T. Pease, Principal, Veterinary College, Punjab, who was on the eve of retirement from service. In order to ensure a regular progress, especially in research, he thought that it would probably be found desirable to have in India a strong Central Board of Agriculture, organized somewhat on the basis of the Board of Agriculture and Fisheries in England, or of the Boards of Agriculture in Scotland and Ireland, and that, if such a policy was accepted, veterinary science would no doubt be represented.

The agenda of the meeting comprised 12 subjects. An interesting discussion followed the introduction of the subject of veterinary education by Col. G. K. Walker, and a sub-committee under the chairmanship of Lieut.-Col. A. Smith, Principal, Bengal Veterinary College, was appointed to deal with the question. The sub-committee considered that the small number of recruits annually required for the imperial branch of the department would not justify the very large outlay necessary to establish an efficiently equipped college for the provision of higher veterinary education in India as recommended by the Public Services Commission, and they, therefore, suggested that in order to assist Indians to qualify for the imperial branch of the service, selected youths should be sent to Europe by the aid of State scholarships. As regards the education required for the different grades in the provincial services, they recommended that this should be provided at the existing veterinary colleges, all candidates going through the same curricula with post-graduate courses for the higher grades: that the educational qualifications for entrance to the colleges should be raised: that the prospects of veterinary graduates should be improved: that the course of instruction should be extended over four years instead of three as at present: that the curriculum should be on the lines prescribed for the Royal College of Veterinary Surgeons and that a detailed syllabus should be prepared by the principals of the Indian colleges for final consideration at the next veterinary conference. The report of the sub-committee was adopted, and it was resolved that the meeting of the principals of the colleges to revise the curricula should be held in Calcutta.

The advantages and disadvantages of stationary and itinerating veterinary dispensaries, and the possibility of combining the two systems advantageously, were then considered. A discussion of the subject disclosed the fact that the conditions in the various provinces required different methods, and that it was necessary to adopt those found most suitable in each case. However, the conference was of opinion that the importance of establishing veterinary dispensaries with a staff adequate to deal with outbreaks away from headquarters should be impressed on Local Governments and on District Boards.

As regards the revival of the "Journal of Tropical Veterinary Science," which was abolished in 1912, it was, in view of the depleted staff of the department, not considered expedient or feasible to raise the question at present.

In opening the discussion on the necessity for reorganization of the Indian Civil Veterinary Department, Col. G. K. Walker first gave a brief history of the department, in which he showed how its development was marked by vicissitudes, what its legitimate duties were, and how handicapped it was in performing those duties. He then advanced arguments to show that, if the department was to continue to do good work and to progress, a thorough reorganization was necessary. The conference passed the following resolutions on the subject :—

(a) "That this conference is of the opinion that the present constitution and organization of the Civil Veterinary Department is utterly inadequate to cope with the work demanded of it, and they, therefore, respectfully represent to the Government of India the absolute necessity of filling up all existing vacancies in the Indian Civil Veterinary Department without delay, and would emphasize the importance of a large expansion of all provincial departments to deal with the ordinary veterinary work of the country."

(b) "That the department should be placed in a position to deal with the diseases of animals, veterinary instruction, and all operations for improving the breeds of horses and agricultural stock in India."

(c) "That the Government of India should be asked to include in the List of Officers of the Civil Veterinary Department, the names of all officers of provincial cadre, classified under separate provinces."

(d) "That a central authority in the person of a Director-General is required to initiate and co-ordinate the work. He should be a specially selected officer with experience in each branch, if possible, and he should be given some measure of authority over the officers of the department."

Sub-committees appointed to deal with a part of the question reported on the strength and constitution of the imperial and provincial branches necessary to carry out the duties of the department, and recommended a revised nomenclature of the posts in it.

The next question discussed was—what concerted action can be taken to deal with surra and dourine. Col. Farmer said that the spread of irrigation had led to an expansion of surra in areas where the disease had not previously occurred, and that the practice of keeping horses in the stable between 7 A.M. and 7 P.M. gave very satisfactory results. It was pointed out that there was a constant risk of the introduction of the disease from Indian States where the Glanders and Farcy Act could not be applied. Regarding the treatment of surra, several members referred to having obtained promising results, though on a limited scale, and all emphasized the urgent necessity for further experimental research in this direction. As regards dourine, the diagnosis of which was frequently difficult, the conference was of the opinion that the provisions of the Dourine Act should be so modified as to make diagnosis on clinical symptoms fall within its cognizance.

In dealing with the question of applicability of the different methods of inoculation against rinderpest to conditions in India, the conference resolved, that when an adequate and sufficiently trained staff was available, the question of adopting the simultaneous method of inoculation more generally might be taken up as being more economical and more effective.

Several officers expressed their views as to the prevalence of bovine tuberculosis in the various provinces, and referred to the unsatisfactory results following the subcutaneous injection of tuberculin in India, upon which, Mr. Sheather suggested the application of the ophthalmic test. The conference emphasized the urgent need for investigation of the whole question of tuberculosis in India.

In connection with the question of the control of rabies in India, the conference considered that any suitable measure that could be adopted for reducing and destroying the surplus population of dogs was desirable, but that it did not appear to be possible under the conditions prevailing in India, to deal more effectively with the disease. Power should, however, be given to veterinary practitioners to order the detention and destruction of dogs suffering from rabies.

The need for research had been strongly emphasized throughout the discussions of the conference, and when the question as to the method by which it should be brought about came up for consideration, the conference passed the following resolutions :

(*a*) "That in order to deal with the physiological problems of animal husbandry in India, it is necessary to have a fully equipped Central Research Institute with an adequate staff. The Muktesar and Bareilly laboratories, if the necessary staff is supplied, might be developed into a Central Institute of the kind proposed. In view, however, of climatic and other considerations, it may be necessary to consider alternative sites. The staff should be sufficient to permit of the deputation of officers to work out problems in collaboration with provincial veterinary officers either at provincial laboratories or in the field."

(*b*) "That the conference is in favour of the creation of a separate organization for the study of the insect parasites of men and animals, the connection with the Civil Veterinary Department being on the lines suggested by Mr. Howlett in his note."

With regard to the question as to whether, in view of the sectional meeting of veterinary officers, it will be necessary for them to attend the full meetings of the Board of Agriculture in India, the conference considered that it should be left to the Agricultural Adviser to determine whether veterinary officers should, in consideration of subjects coming up for discussion, be invited to the meetings or not. In this connection it was recommended that, for the present, meetings of veterinary officers should be held annually, and that all members of the Civil Veterinary Department should be invited to future meetings.

The conference was of opinion that some form of legislation was necessary to deal with cattle diseases, especially as regards segregation and the movements of cattle, and that such legislation should be introduced when possible.

In dealing with the question of the animal industry in India the conference was of opinion that, except in special cases where rapid milk production was required, and where efficient control was established, the general importation of exotic breeds of cattle should not be recommended at present, and that the main policy should be the improvement of indigenous breeds by selection.

The conference, from the veterinary point of view, was very successful and valuable. A detailed report of the proceedings is in the press and will be issued in due course.

VETERINARY RESEARCH: SOME RECENT CONTRIBUTIONS.

BELIN, M.—THE TREATMENT OF EQUINE LYMPHANGITIS BY PYOTHERAPY. *Receuil de Méd. Vét.*, 1919, Vol. XCV, No. 4.

The author describes a new technique for the preparation of the vaccine.

The pus is collected in a sterile flask. One part by volume (presumably an equal amount) of ether is added and the flask is shaken until the pus is broken down as much as possible. To this are added six "parts" (presumably six times the amount) of a solution containing 0·1 per cent. iodine and 0·4 per cent. potassium iodide in distilled water. This is added in two or three parts.

It is advisable to filter through several layers of sterile gauze. The vaccine can be used half an hour after preparation. (It may be pointed out that the description of the technique in the original leaves much to be desired.)

In practice the author has mixed together pus from numbers of cases of cryptococcic and bacterial lymphangitis for the preparation of his vaccine.

In the case of cryptococcic lymphangitis the author is in favour of giving a series of injections instead of the method advocated by Velu of giving single injections during the negative phase of the disease. He finds it more practicable when large numbers of cases have to be treated daily.

In the bacillary lymphangitis cases, the author has [illegible] his original method of giving an initial series of four [illegible] followed by an injection every five or six days until [illegible] is complete.

The production of abscesses at the seat of inoculation is not, in the author's view, due to a ferment action as suggested by V., but to a special sensibility of certain animals to dead or attenuated bacteria in general and to cryptococci in particular.

It appears to be immaterial by what path the vaccine is introduced. In the case of intravenous injections there is the advantage that no local lesion results. In this connection it may be noted that the author has had two animals die while under treatment. In one case death was considered to be due to ante-mortem intracardiac clotting of the blood, and in the other, to endocarditis. It is suggested that in both cases death was a matter of coincidence.

In the author's opinion it is advisable to give a dose of 2 c.c. daily for six or seven days. From twelve to fifteen days after the last dose, provided the lesions fail to disappear or fresh abscesses are formed, a second series of injections of 2·5 c.c. of "sterilized pus" is given. (By using the expression sterilized pus it is not clear whether the author means his vaccine or not, and it may be pointed out that in view of the dilution of the pus in making the vaccine this is a point of some importance.)

The author briefly describes a number of cases in which the vaccine has been used in chronic cases of the disease, and draws the conclusion that the vaccine is actually responsible for the cures in these cases, and that the view that recovery has been spontaneous is mistaken.

VELU, H.—AN UNDESCRIBED DISEASE OF THE DOG IN MOROCCO. *Bull. Soc. Path. Exot.*, 1919, Vol. XII, No. 3.

In this paper the author describes an acute disease of the dog characterized by marked nervous, pulmonary and digestive symptoms.

From references given, it would appear that the disease has been observed in other parts also. Heckenroth describes it as occurring in Senegal, and Labouisse in Mogador.

The disease broke out at some distance from Casablanca in August, 1918, and within a couple of months, the majority of the dogs in neighbouring districts had died. A few isolated cases were observed in Casablanca itself.

Nervous symptoms always predominated, and presented a picture which suggested the possibility that the disease was in reality rabies.

From the outset, the cases were marked by inco-ordination of movement and slight paralysis. In many cases the animals stood on their fore legs only, the hind legs being almost, if not entirely, lifted from the ground.

Choreiform contractions of various parts of the body were observed together with champing of the jaws and retraction of the commissures of the lips.

Sensation was also "modified."

The respiratory symptoms were restricted to the upper air passages, and consisted of rhinitis with, at first, a serious discharge which later became muco-purulent. There was a painful cough resembling that of whooping cough, and subsequently symptoms of suffocation.

The appetite was normal, but affected animals vomited after every meal, especially in the early stages of the disease.

In the majority of cases, the affected animals died in from 8 to 10 days. Some survived a month, and some made a complete recovery.

Post-mortem examination, bacteriological investigations and inoculation experiments have yielded entirely negative results.

PIOT BEY.—THE RECRUDESCENCE OF CATTLE PLAGUE IN EGYPT. *Ann. Inst. Past.*, 1919, Vol. XXXIII, No. 3.

The good results following the introduction of the simultaneous method of inoculation against cattle plague among the animals on the State Domains led the Government of Egypt to order the systematic and general application of the method with the object of completely eradicating the disease from the country. Excellent results had been obtained and the work was progressing satisfactorily up to 1914 when events caused an interruption in the work. In some way or other cattle plague reappeared in the country, and during the following year spread through Upper Egypt and to practically the whole of Lower Egypt. While there was a considerable stock of serum at the Institute at Abbasieh, virus that is to say virus derived from cattle imported from Cyprus, was unobtainable owing to the closing of the Institute. Rather than use blood from indigenous animals, which are frequently infected with one or more kinds of piroplasms, for virus, the expedient was tried of rubbing the exposed mucous membranes with cotton wool saturated with virulent exudates from infected animals.

This method however proved almost invariably ineffectual, and it was therefore decided to return to the original method of using virulent blood.

The state of affairs in August, 1917, on the State Domains was as follows :—

(1) There were about 1,400 cattle which had been vaccinated in 1912, 1913 and 1914.

(2) 281 adults and 395 calves of from two to three years of age, bought in 1916 and 1917, which had not been vaccinated. The calves were collected into herds of from 40 to 100 on the seven principal farms.

On August 5th, the first suspected case was reported among a herd of 96 animals of two years of age. The next day but one temperatures were taken and 12 animals shewing marked elevations were detected, and one of these was also shewing clinical symptoms. The following day this animal received about 120 c.c. of serum as a curative measure.

On August 8th, the blood of one of the animals was used as virus for the simultaneous inoculation of the other 11. This blood was kept on ice until the following day when it was used together with serum, which had in the meantime arrived, for the inoculation of the remaining 83 animals.

It is here noted that the blood used was found to contain Piroplasm bigeminum.

During the following days the animals were under careful observation and their temperatures were taken twice daily. The animal which had been given 120 c.c. of serum died on the night of the 10th with very severe lesions.

Of the 11 calves vaccinated on the first occasion, six shewed lesions on the same evening or on the next day. The same thing occurred in the case of one of the animals vaccinated on the 9th.

Of these 7 animals (this appears to be a misprint for 87) five died with characteristic lesions and two recovered. This is the usual proportion of recoveries in Egypt.

In view of the fact that 87 of the animals gave reactions to the inoculations, it is evident that they were susceptible.

In view of the result obtained, it was decided to extend the vaccination to all the unvaccinated animals and also to all animals that might be bought subsequently.

The virus used for the inoculations was obtained from two calves inoculated in series and kept in a portable ice chest for eight to ten days.

Six series of calves were inoculated fortnightly and this served to keep the virus going until the end of November.

From August 26th to 28th, 299 calves and 281 adult animals were immunized. The virus used was found to be free of piroplasms, as it was also in the five subsequent series of virus producers.

From September 2nd up to October 24th, five lots of cattle numbering 178, purchased during this period, were inoculated.

Seventeen of the animals bought during this period had been vaccinated during 1912 and 1913, and these were not revaccinated. None of them shewed infection.

It has already been seen that 98 per cent. of the first batch of calves reacted to the inoculations. In the case of three other batches numbering from 49 to 50 head, the percentages of reactions were 79, 83, and 76.

Among three lots of animals aged about three years, the percentage of reactions ranged from 68 to 77.

These figures indicate that increasing age gives increasing immunity.

This view is supported by the fact that of 459 adult animals vaccinated during the same period, only 229 reacted.

The author points out that in a previous paper he expressed the view (basing his opinion on two experiments) that immunization of the mother alone is practically without result, but th... inocula... tion of both parents appears to confer complete immun...

A fresh observation in support of this is brought forward, b... definite opinion is reserved.

A calf, twenty-eight days old—the progeny of anim... vaccinated respectively in 1914 and 1915—was inoculated along with its mother as a test on 27th August, 1917. Neither shewed any reaction to the double inoculation.

While no accidents occurred among the first batch of animals inoculated, it is pointed out that a few occurred among the animals done subsequently.

Of the two-year old calves, one died on the 13th day and ... on the 17th day after inoculation.

The first of these shewed embolism of the left ventricle of the heart and evidence of atelectasis and embolism in the lungs. The animal had shewn a marked reaction to the inoculation and at the post-mortem the lesions of cattle plague were becoming cicatrized.

The second animal was in poor condition at the time of inoculation. It passed through a normal reaction which was followed at an interval of some days by a sudden rise of temperature to 40° accompanied by violent bile-stained diarrhœa, and complete loss of appetite. The animal died on the third day after the appearance of symptoms. At the post-mortem there was slight enteritis and marked congestion of the lungs: no enlargement of the liver or spleen and no evidence of piroplasmosis.

Among the 459 adult animals inoculated, there were also two accidents, both of which occurred among a single batch of newly purchased animals.

The first of these died on the 14th day after inoculation as the result of a severe attack of Texas fever complicated by tuberculous abscesses in the lungs.

The second animal died 17 days after inoculation having shewn vague symptoms of "malaria" and spasmodic contractions of the masseter muscles.

At the post-mortem examination, the spleen was found to be very greatly enlarged, and there was congestion of the intestines and lungs. There was no hæmaturia and no red serous exudate in pericar ium.

Neithe of these animals had reacted to the inoculation.

If thes deaths are considered to have been due to the vaccina-n, it in no way discredits the method, because similar deaths have en observed in very large numbers of cases among newly bought imals which have not been inoculated.

The facts collected during the course of the outbreaks referred in this paper shew that immunity conferred by the simultaneous oculation method persists for periods of at least five years. None the animals inoculated during 1912-13 shewed the slightest sign being infected, although no special precautions were taken to otect them from infection.

COCONUT: THE WEALTH OF TRAVANCORE.*

BY

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INTRODUCTORY.

TRAVANCORE, that narrow strip of territory at the south-western corner of India, stretching from Cape Comorin in the south to Cochin in the north, having a length of about 174 miles from north to south, a maximum breadth of about 74 miles from east to west, and a total area of about 7,600 square miles, and inhabited by a population of about $3\frac{1}{2}$ millions, is the largest and most prosperous Native State in the Madras Presidency. In point of size it is only about one-fourth ot the State of Mysore ; but its revenue is more than one-half of that of the latter. Every foreigner, who visits the country, is enamoured of the richness and splendour of its natural resources that at the very first sight he calls it a land overflowing with milk and honey. Though this is an exaggeration, it is not without a small substratum of truth. Poverty there is in plenty in Travancore as in other parts of India ; but entire pauperism and absolute starvation are not so common as in other parts. Though occasionally crops fail on account of scarcity of rains, the country has never been visited by one of those dire famines which have at different times caused indescribable havoc and enormous loss of life in British India. What is the cause of this significant difference between Travancore and other parts of India ? Rice, which is the food of the people, is not being produced in sufficient quantity to meet local requirements

* A paper read at the Fifth Indian Science Congress, Lahore, 1918

though it is the chief crop of the country. Local production amounts to only two-thirds of the quantity required, while one-third is being imported from Burma and other countries. Self-sufficiency in the matter of food production is not, therefore, the cause of the happiness and contentment of the people of Travancore. What else can it be due to? The answer will be self-evident to one who takes a trip in a boat through the long stretches of backwaters which extend practically along the whole length of the country. There one will see on either side miles and miles of lands covered over with thick and luxuriant groves of that beautiful and attractive species of the palms which botanists call *Cocos nucifera* and which is familiarly known to laymen as the coconut palm. It is this palm which has contributed mainly to the present prosperity of Travancore. From it the people derive their main income and from it the Government gets a large portion of its revenue. There is no part of it which is not useful in one way or another. The kernel inside the nut, which is the most valuable part of the coconut products, is used in India for culinary purposes either as such or in the form of oil which is extracted from it, and in Europe it is made into sweets, biscuits, and other articles. The coconut oil, which is the essential portion of the kernel, is being largely used in the manufacture of margarine, coconut butter, soaps, and candles. The cake, that is left behind after the oil is extracted, is a valuable cattle food and a still more valuable manure. The milk especially of tender nuts is a delicious drink the excellence of which can only be appreciated by those who have had the fortune to quench their thirst with it after a tiresome walk or a long ride. The juice, which is collected from the unopened spadix, when fresh and unfermented, is an equally refreshing drink ordinarily known as toddy; when partially fermented it becomes a slightly intoxicating drink; and when fully fermented and distilled it yields an alcoholic drink called *arrack*. The shell, which covers the kernel, is excellent fuel, and takes the place of coal in Travancore. The husk surrounding the shell, when soaked in water for about six months, washed, and cleaned, becomes coir from which yarn, cables, ropes, matting, foot-rugs, and various other articles are made. The dried sheaths of flowers are used as fuel, the leaves when dried are plaited form excellent material for thatching houses, and the stem when fully mature makes fine beams and rafters for buildings. Here is a tree which supplies food and drink to man and gives him materials to construct a house to live in, and well does it deserve the name "Devavriksham" or "Kalpavriksham" (the tree of heaven), a name which has been ascribed to it in the ancient Indian literature, and which is still current among the people of the Malabar Coast.

ORIGIN OF COCONUT CULTIVATION.

As regards the origin of coconut cultivation in Travancore, different theories have been advanced. Some are entirely based on legends and others on linguistic and other evidences. The legend most widely believed by the people is that "Kerala," which is but another name for Travancore, was once under the sea and was reclaimed by the magic wand of God Parasurama, that the reclaimed country was parcelled out and distributed to a number of Nampudiri Brahmins whom Parasurama brought from the north, and that the "Kalpavriksham," the coconut palm, was given to the colonists by him as a heavenly gift. It is difficult to sift the chaff from the grain in such legends and to get at the truth underlying them, if any. There is, I believe, geological evidence to show that Travancore has been formed by the rise of the sea-bed by some movement of the earth, and there is also linguistic evidence to support the theory that the coconut palm is an introduction into the country from outside. Out of these facts the fertile brains of the ancient Indians must have woven the story of Parasurama, giving it a religious cloak, so as to appeal to the minds of the illiterate masses. This is all the justification that one can find for the Parasurama legend.

Coming now to the hypotheses based on linguistic evidence, it must be said that there is no unanimity of opinion regarding them. The one that is generally accepted is that "keram," a contracted form of "nalikeram" which is the Sanskrit word for coconut, was brought to India from Ceylon by the Singhalese, who crossed over somewhere about the 4th century A. D. and who now form the large and progressive community of "Thiyyas" or "Eshavas." "Thiyyan" is considered to be a corrupt form of "Dwipan" or islander, and "Eshava" a corruption of "Simhala" or "Singhalese," the natives of Ceylon. The "keram," which the Singhalese imported, is also said to have given the name "Kerala" to the country in which it has thrived. The Tamil and Malayalam names for coconut lend support to the above theory. The Tamil name "Thenkai," from which the Malayalam name "Thenga" has been derived, means the fruit from the south ("Then" means south and "kai" fruit, i.e., the fruit that was brought over from the south, presumably Ceylon). This theory appears to be plausible even on a consideration of the commonly accepted hypothesis about the original home of the coconut palm. Some are of opinion that it is a native of South America, while others think that it belongs to some islands in the Asiatic Archipelago, most probably Sumatra and Java. The latter appears to be more probable and is at any rate accepted by the majority of those who have investigated the question. From the evidence that has been collected it is not far wrong to infer that coconut was carried by oceanic currents from the Asiatic Archipelago eastward to South America and westward to Ceylon, and that from the latter place it was imported into India. Whatever be the source from which the palm has been introduced, there is no doubt that it must have established itself in the Malabar Coast from very early times. The ancient Sanskrit literature dealing with the Ayurvedic system of medicine contains many references to the medicinal properties of the different coconut products, which is sufficient proof of the antiquity of coconut cultivation in India. When once it has been introduced and its uses have become known to the people, the development of its cultivation must have taken place as a natural sequence of events.

COCONUT INDUSTRY IN TRAVANCORE.

For a very long time, however, the uses of coconut products were little known outside India and probably even outside the Malabar Coast. When Europeans first opened trade with ... they took no notice of this palm and its produce. Pepper was then the chief article exported from the Malabar Coast, and the territory which produced it in abundance was known among the Europeans as the land of pepper. With the advancement of sciences in the 19th century it was discovered that various highly useful and valuable articles could be manufactured out of coconut products and a demand thus arose for them in European markets. Till the outbreak of the present war Germany was the chief country to which these articles were exported, and there they were made use of in the manufacture of soaps, candles, margarine, etc. The magnitude of the export trade of Travancore in coconut products could be realized from the fact that during the three years before the outbreak of the war she exported on an average Rs. 1,82,00,000 worth of these articles annually, which represented nearly 50 per cent. of her export trade. The articles exported were chiefly raw products such as coconuts, *copra* (dried kernel), oil, coir, and fibre which together accounted for nearly Rs. 1,65,00,000. The position of coconut among the factors contributing to the prosperity of the country, to which I have already referred, will be evident from the above figures. I have also referred to the fact that Travancore imports one-third of the rice she requires for local consumption, *i.e.*, for about Rs. 1,25,00,000. The people grow coconut and sell its produce in foreign markets, and with the money thus received they buy rice from outside. But for the abundance of coconut produce and the large export trade that has become possible in consequence, the people would not have had sufficient money with which to buy the rice so essential to their living, and their lot would then have been quite different from what it is at present. Fortunately for them the country is so plentifully blessed by Nature, and the soil and climatic conditions are so congenial to the growth of the coconut palm, that they are able to get a handsome return from it without much labour or trouble. But, with better attention and care in the matter of cultivation and manuring, it is possible to increase considerably the income from this crop. The people, I am glad to say, have begun to realize the folly of not utilizing the blessings of Nature to the utmost advantage, and are at last bestirring themselves in the development of their coconut cultivation.

The area under coconut in Travancore is not after all much, and the outturn is not anything like what it is capable of yielding. Unfortunately there is no agency in Travancore for the collection of annual agricultural statistics and for the publication of periodical crop forecasts. It is not possible, therefore, to give accurate information about the acreage and yield. On a rough calculation it is estimated that out of the total area of the State (4,864,000 acres), coconut occupies only about 250,000 acres, and that the total output of nuts in a year may amount to about 500 millions on the assumption of an average yield of 2,000 nuts per acre, which, if anything, is but a conservative estimate. The export of *copra*, oil, and nuts accounts for about 325 million nuts out of the total production, and the balance of 175 million nuts is being consumed in the country itself. The export of 325 million nuts before the war brought into the country a sum of Rs. 1,82,00,000. If by paying better attention to cultivation and manuring the output of coconuts is doubled, which I shall show is not an impossibility, the quantity available for export will increase to 825 million nuts, which will raise the national income from coconut products to not less than five crores of rupees even if the export is confined to raw products such as *copra*, oil, coir, etc. These are being sent to foreign countries for being manufactured into different finished articles, and if this manufacture is undertaken in the country itself, there are immense possibilities of increasing its natural wealth still further. The very thought of this question overwhelms one with the vastness of the field that unfolds itself before the mind's eye for the development of the natural resources of even such a small State as Travancore, and what can one say then of the potentialities of such a vast continent as the British Empire?

CULTIVATION OF THE PALM.

Before proceeding to show how the coconut industry of Travancore ought to be developed, I shall describe as briefly as possible how the palm is now being cultivated. It thrives best on the littoral area, particularly on that portion of the country which lies between the sandy deserts of the coast and the sub-montane tract of laterite formation to the east of the backwaters. The soil best suited for it is a loose and friable sandy loam, which is generally met with in the area specified above. Looseness of soil which will admit of the free passage of roots, is an essential condition to the successful growth of the coconut palm. Richness of plant foods seems to be a less important factor. If the soil is poor but loose, the roots will grow to a length of 20 to 25 ft. in search of food and will make good use of the materials available within that wide radius. On the other hand in a soil which is hard and impervious, however rich it may be, it does not show a healthy growth, unless such a soil is made friable by the addition of sand and lime. Abundance of moisture seems to be as essential to the growth of the coconut palm as looseness of the soil. Travancore has a rainfall varying from 30 to 250 inches per annum. She gets the benefit of both the south-west and the north-east monsoons which together cover a period of about seven months in the year, from June to December and the only dry weather that she experiences is during the months of January to May. In places where the heat is most severely felt the coconut palm is irrigated during these months, and at other places the soil is worked up to such a fine condition just before the cessation of the rains as to conserve sufficient moisture to enable the palm to tide over the hot season without much injury. If irrigation can be resorted to in such places the yield can no doubt be increased. But irrigation in these places is impracticable, and hence cultivators have to be satisfied with the diminished yield they get. Though a loose sandy loam is the ideal soil for the cultivation of the coconut palm, it is by no means confined to such soils in Travancore. The cultivation is being extended practically over all kinds of soil. The sandy deserts along the coast which contain little or no plant food, the heavy clay soils reclaimed from the backwaters, and the infertile lateritic soils of the hills and hill-slopes in the interior of the country are all being brought under this crop, the natural defects of the soils being rectified by artificial methods. The sandy deserts are enriched by the addition of rich silt from the backwaters, the fertile but impervious soils reclaimed from the backwaters are made porous by the addition of sand, and the poor laterite soils of the hills are improved by the addition of sand and manures. By these methods almost every kind of soil met with in the low-lying and sub-montane parts of Travancore, where the climate is warm and moist and the temperature remarkably equable all the year round, varying only from 70° to 90°, has been made suitable for coconut cultivation. The only limiting factor is the presence of a hard and impervious sub-soil. Where the sub-soil is soft and porous to a depth of about 4 to 5 ft., there the coconut palm grows satisfactorily. Even steep slopes which satisfy this condition are being used for the purpose by forming terraces to prevent washing and to conserve rain water.

Among the varieties of the coconut palm met with in Travancore as many as 40 have been counted. They differ from one another in various points, such as colour, shape, and size of the nuts, thickness of the outer fibrous covering, thickness of the kernel inside, the oil-content of the kernel, and the period of maturity of the palm. In colour, different shades of green, brown, and yellow are met with. According to the size the nuts can be classified as small, medium, and large. The thickness of the fibrous covering and of the kernel and the oil-content vary considerably in different varieties. Under normal conditions some varieties begin to bear in 3 to 4 years and others in 7 to 8 years, and on this distinction the coconuts can be classified as early and late varieties. The life of early varieties is not more than 20 to 25 years, while the late varieties may live up to 100 years and more. In the selection of varieties for cultivation all the above factors, except perhaps colour, must be taken into consideration. The ideal variety is one which has the longest life and which produces medium-sized nuts having a thin fibrous covering, thick kernel, and high oil-content. Owing to the lack of sufficient care in the selection of seeds several undesirable varieties have been cultivated in Travancore, but through the advice of the Agricultural Department there has come about a decided improvement in this direction in recent years.

The seed nuts are usually collected from middle-aged ...
The nuts which ripen in the dry months of April and M...
sidered to be the best for seed. In harvesting the

cultivators take great care to prevent injuries to the embryo. The nuts that are collected are stored in buildings for a couple of months during which period they dry up to some extent and lose a great portion of the milk inside. They are then planted in specially prepared nurseries, usually in July. In a couple of months after planting the nuts germinate and in next June they will have thrown out or 4 leaves when the seedlings are transplanted. On low lands which are subject to inundations, experience has taught the ryots that it is better to plant 2-year-old seedlings. On laterite soils also, where there is trouble from white ants, it is advisable to plant 2-year-old seedlings only. Though the usual time of transplantation is the commencement of the south-west monsoon in order that the plants may establish themselves without the help of irrigation before the setting in of the hot weather in the month of December, it has been found from practical experience that if the seedlings are transplanted in December and irrigated during the first hot weather they become hardier and are able to withstand drought in subsequent years better than those transplanted in June. Of course, this method can only be adopted in places where there is facility for irrigation.

In low lands subject to water-logging the seedlings are planted on ridges which are made at first 10 to 15 ft. broad and at least 2 ft. above the water-level. As the seedlings grow up, the trenches in between the bunds are filled up and the level of the whole land gradually raised until it is at least 3 to 4 ft. above the water-level. On elevated lands, which generally contain laterite soils, the seedlings are planted in pits, the size of the pit varying in proportion to the height of the land and the hardness of the soil. The biggest pits measure at least 4 ft. cube of which about 2 ft. are filled with surface soil and manure before the seedlings are planted, and the remaining 2 ft. are gradually filled up during the first 3 years after planting.

Among coconut cultivators of other countries the question is still under discussion whether it is advisable to cultivate catch crops on coconut gardens. In Travancore it is invariably the practice to grow such crops, especially on lands which are not poor in plant foods, for the first 4 or 5 years. The crops that are usually cultivated are cassava, other roots, pulses, banana, and dry land rice. Of these, cassava seems to be the least suitable, not because it is more exhausting than other crops, but because it is ordinarily cultivated without manures, while cattle dung, ash, green leaf, and other manures are usually applied to other crops. It is a bad practice to cultivate any catch-crop on coconut gardens without the application of manures, for in that case the soil fertility will soon get exhausted, and the growth of the coconut palm will to that extent be affected. But if catch-crops are manured properly, there is no danger in cultivating them for the first 3 or 4 years after transplanting the coconut seedlings. In the interests of the coconut as well as of the catch-crops it is advisable not to raise the same catch-crop every year. Different crops must be cultivated in rotation, prominence being given to pulses, and this is what is being done in Travancore.

In the matter of manuring there is much room for improvement in the methods of Travancore cultivators. They are no doubt aware of the fact that manuring will pay; but owing to want of capital and sometimes owing to their negligence and indifference they are not doing all that they ought to do in the matter. At the time of transplanting they invariably apply some ash and a small quantity of common salt. This they do more with a view to prevent the attack of white ants on the seedlings. Subsequently most of the cultivators apply ash regularly every year, and some also cattle and sheep manure, green leaf, and occasionally some common salt as well. It is a common practice among them to apply a mixture of ash and salt to the crown of the palm which has been found to be an effective method of keeping off beetles. These manures will naturally be washed down to the ground by the rain and will become available for absorption by the roots. Thus two birds are killed with one shot.

We have already seen that one of the chief factors that contribute to the successful growth of the coconut palm is moisture, and that, except during the hot weather period of about five months, the rainfall in Travancore is sufficient to ensure the supply of the required moisture to the soil. During the hot weather irrigation is not resorted to except in some portions of the sandy district along the coast; but in other places cultivators have found out from practical experience an efficient method for the conservation of moisture in the soil. In June, at the commencement of the south-west monsoon, beds are taken around the palms in order to collect rain water and let it percolate through the soil. By this method surface washing is reduced and the porous soil and sub-soil are thoroughly soaked. The rains continue till December, when the beds are filled up and the whole garden is given a thorough digging to a depth of a foot or so. By this digging the weeds are covered and the soil is reduced to a fine tilth, which helps in the conservation of the moisture that has been absorbed by the soil during the rainy season. A more efficient, but less expensive, method of utilizing to the best advantage the natural rainfall in the cultivation of the coconut palm than the one described above, it is difficult to think of.

From what has been said regarding the methods of cultivation commonly followed in Travancore, it will be seen that there are several excellent practices which the cultivators have learned from their long experience, and which can safely be recommended for adoption in countries where they are not known. Prominent among these are: (1) the addition of silt to sandy soils and sand to clay soils to correct the natural defects of soils; (2) the terracing of slopes to prevent surface washing; (3) the principles of the selection of seed nuts and the care bestowed on their collection; (4) the application of ash and common salt to the soil before transplanting the seedlings to prevent the attack of white ants; (5) the planting of 2-year-old seedlings on lands subject to inundation and on hilly lands where there is white ant trouble; (6) the cultivation of catch-crops between coconut palms for the first 4 or 5 years; (7) the application of ash and common salt to the crown of the palm as a preventive against the attack of beetles; (8) and last, but not least, the practice of making beds around the palms in June and of filling them up and digging the whole ground in December in order to collect and conserve as much as possible the rain water and utilize it to the maximum benefit in coconut cultivation.

IMPROVEMENTS BY AGRICULTURAL DEPARTMENT.

By giving prominence to the good points in the methods of Travancore cultivators, I do not mean to say that their methods are perfect, nor that the practices referred to above are being adopted by all of them. There are many in Travancore who, out of ignorance or indifference, do not follow these practices, and one of the chief functions of the State Agricultural Department is to break this citadel of ignorance and indifference and to extend throughout the country the excellent methods that are being practised in some parts. Along with this work the department is also devoting its attention to the general question of the improvement of coconut cultivation in regard to certain aspects which are little known to Travancore cultivators, and which, though known, are neglected by the majority of them. I shall describe as briefly as possible the work that is being done by the department in this direction.

One of the chief defects of coconut cultivation in Travancore is overcrowding of the palms. Where there ought to be 50 to 70 palms only, 100 to 150 are usually planted. The evils of overcrowding are self-evident. In a thickly planted garden the palms at the periphery are found to be more productive than those in the interior, though there is no difference in the treatment. Those at the periphery get more light and air and hence are in a better condition. It cannot be said that Travancore cultivators are ignorant of the evils of overcrowding. There is a proverb current among them regarding the distance at which the palm is to be planted, and if they had only followed this wise saying of their ancestors they would not have made mistakes. The proverb says that on low lands the distance between the palms should be 4 *dhannus* (a dhannu = 10 ft.) and on high lands 3 *dhannus*. The proverb, if anything, errs only on the right side. A distance of 30 to 40 ft. appears to be more than the actual requirements. 25 to 30 ft. seems to be ample—30 ft. on low lands and 25 on high lands—and in that case the number of palms to the acre will be 50 to 70. In recent plantings, I am glad to say, these distances are being adopted.

In regard to the selection of varieties, we have ... that the methods of Travancore cultivators, or ...

of them, are far from primitive or unscientific. The main objects of seed selection are to produce the maximum number of nuts and the maximum quantity of *copra* per acre (the dried kernel is what is called *copra*). Of the different varieties met with in Travancore there are some which require only 1,200 to 1,500 nuts to make one *candy* (800 lb.) of *copra*; while in the case of others the number required goes up to 2,000 and 2,500. Varieties of the former class which yield nuts of medium size, must be selected for planting. In the case of large nuts the number per acre will be proportionately small; and in the case of small nuts, though the number may be large the kernel inside is so thin that the quantity of *copra* obtained from an acre will be comparatively less. The golden rule to be observed, therefore, is the selection of medium nuts with thick kernel. This rule has not been universally followed in the past, and hence very many undesirable varieties have come into actual cultivation. To prevent the repetition of this mistake, the Agricultural Department has during the last two or three years selected nuts of the desired types and sold them to the public. This work is being continued, and to enlarge its scope the department has also assisted in the formation of a private firm to carry on the same work.

The greatest possibilities in the improvement of coconut cultivation in Travancore lie in the method of manuring, and it is the solution of this question that has engaged the prominent attention of the Agricultural Department during the past seven or eight years. The department has carried out a number of experiments with different manures, most of which are still being continued, and has obtained highly encouraging results. The majority of soils in Travancore, except those bordering on the backwaters and the alluvial deposits on the banks of rivers, are deficient in humus, nitrogen, phosphoric acid, and lime. From a number of samples of soils analysed, it is found that the composition varies somewhat as follows: Nitrogen, 0·06 to 0·17 per cent.; phosphoric acid 0·01 to 0·05 per cent.; and potash, 0·20 to 0·30 per cent.

The only plant foods which are present in anything like satisfactory quantities are potash and in some cases nitrogen also; but ven these cannot be considered sufficient for the requirements of the coconut palm. It has been calculated that a crop of 2,000 nuts per acre will remove from the soil about 18 lb. of nitrogen, 5 lb. of phosphoric acid, and 38 lb. of potash. If the requirements for the growth and nourishment of the palm are also taken into account, the quantities of plant foods to be added to the soil annually, in order to prevent its deterioration, must be not less than 24 lb. of nitrogen, 12 lb. of phosphoric acid, and 60 lb. of potash. This is of course in the case of a soil of medium fertility. But in the case of soils which are exceptionally poor in phosphoric acid and to some extent in nitrogen also, but fairly rich in potash, as Travancore soils are, the first two must be added in larger quantities, and the last in somewhat less than in the usual proportions. Travancore soils also contain very little lime, and lime is essential to such a longstanding crop as the coconut palm to neutralize the acids that are formed in the soil and to improve its general texture. Common salt has been found to be a valuable manure to the palm. The Travancore ryots have learned it by experience, and the scientists have declared from their analyses that as much as 60 lb. of sodium chloride are removed from an acre by a heavy crop. Near the coast, where there is the possibility of the sub-soil being infiltrated with brackish water, the application of common salt can be dispensed with ; but in other places it is indispensable. Keeping the above facts in mind, I have prepared a manure for the coconut palm consisting of ingredients available in Travancore. I have not gone in for artificials because they are not easily available, and, even if available, they are too costly to become widely popular in the near future. My mixture consists of 10 lb. of oilcake, 20 lb. of ash, 2 lb. of fish refuse, and 1 lb. of common salt per tree. In the place of fish refuse bonemeal can be substituted, and in soils whose lime contents are poor, 10 to 15 lb. of quicklime are also added once in 2 or 3 years. The above mixture has the following average composition: Nitrogen 0·53 per cent., phosphoric acid 1·01 per cent. and potash 0·74 per cent.

Several experiments have been carried out with this [illegible] both by the Agricultural Department and by private [illegible] the supervision of departmental officers, and all of them have produced exceptionally good results. I shall give here the results of a few such experiments.

Serial No.	No. of palms manured	Year	Total produce in nuts	Average yield of nuts per palm
1	10	1909-10	44	4·4
		1910-11	67	6·7
		1911-12	223	22·3
		1912-13	480	48·0
		1913-14	573	57·3
		1914-15	669	66·9
		1915-16	919	91·9
2	100	1912-13	4,000	40·0
		1913-14	7,000	70·0
		1914-15	6,000	60·0
		1915-16	9,000	90·0
3	263	1911-12	11,300	43·1
		1913-14	19,400	73·8
4	250	1912-13	3,989	15·9
		1913-14	9,857	39·4
		1914-15	10,042	40·1
		1915-16	11,862	47·5
5	100	1914-15	1,193	11·9
		1915-16	2,309	23·1
		1916-17	4,167	41·7

The trees in the first series were in a very poor condition at the commencement of the experiment owing to long neglect. The second and third series were conducted on lands of medium fertility and with trees which were not so badly neglected; and the last two series on poor lands and with trees badly neglected for a long time. The statement given above clearly shows that there has been phenomenal increase in the yield of nuts in consequence of regular manuring. The highest yield obtained is nearly 92 nuts per palm. It has taken several years for long neglected trees to produce this yield. Trees which have not been so badly neglected have come up to this standard in four years as the second series of experiments shows. In the last two series the trees were so badly neglected that the yield has only increased to 47 and 41 nuts respectively in three to four years. It is sure to increase still further in subsequent years and come up to the yield of the trees in the first series in another three or four years. The lesson that these experiments teach is that under proper manuring the yield of coconuts will increase to as much as 90 nuts at least per palm per annum. When dealing with the output of coconuts in Travancore in one of the previous paragraphs, I have stated that the average annual yield for the whole of Travancore can be put down at 2,000 nuts per acre. Assuming that the trees are planted at 70 to the acre, this only works out to an average yield of 28½ nuts per tree. The numerous experiments conducted by the Agricultural Department have proved unmistakably that this average yield can be more than trebled. In the face of these facts, does any one still think that the statement I have made in the earlier portion of this paper, namely, that the output of coconuts in Travancore can be doubled, is an exaggeration ? I have been making a special study of the problems of the coconut industry in Travancore, and I am convinced that it has a great future before it, and that the country has in this industry great potentialities for increasing its wealth and for adding to the material prosperity of its population. What is it that has to be done for the development of these potentialities ? The answer is simple. Spread knowledge among cultivators and afford them all possible facilities for the purchase and use of manures. The Travancore Durbar is no doubt doing something in these directions through its Agricultural Department ; but there is a great deal more remaining to be done, and this is all that I can say about the matter in this connection.

PESTS AND DISEASES.

Several other problems connected with the coconut [illegible] are engaging the attention of the Agricultural De[illegible] example, the method of manuring, *i.e.*, whether [illegible] be applied in one complete circle around the palms or in half circle or in one-third circles; the question of breeding coconuts in order to produce a variety possessing all the good qualities which I have referred to when dealing with the selection of seed nuts and several other kindred problems. As no satisfactory solution of these problems has yet been arrived at, I do not propose to deal with this part of the department's work at present. Nor do I wish to take up your time by entering into a discussion of that wide and important subject of pests and diseases of coconut palms. A full treatment of this subject will require a separate paper to itself, and much more time than I have at my disposal now. I may simply mention, however, the serious pests and diseases that Travancore cultivators have to contend against.

Among the pests the most serious are the rhinoceros beetle (*Oryctes rhinoceros*) and the palm weevil (*Rhynchophorus ferrugineus*). Since 1914 a new leaf-eating insect has also been found to attack the coconut palms. The hairy caterpillar of this insect eats away the green blades of leaflets leaving only the mid-ribs. It belongs to the family Limocodidæ, and a similar insect found on coconut palms in British Malabar has been identified by the Imperial Entomologist as *Contheyla rotunda*, Hmp. From all appearance the insect found in Travancore seems to be the same. In Malabar its outbreak was observed for the first time in December, 1916, and in Travancore in December, 1914. The Travancore Entomologist has discovered a natural enemy of this pest in a hymenopterous insect by which it has been found possible to control it.

The coconut palm is subject to many infectious diseases. The commonest of these are: (1) Leaf disease, caused by *Pestalozzia palmarum*; (2) Bud-rot, similar to the one attacking the palmyra palm in the Godavari District, caused by *Pythium palmivorum*; (3) Stem bleeding disease, which has been fully investigated by the Government Mycologist, Ceylon, and which he attributes to *Thielaviopsis ethaceticus*; (4) Root disease, which has been investigated by the Imperial Mycologist, India, and the Mycologist of the Imperial Department of Agriculture, West Indies, and which is attributed to a fungus of the genus *Botryodiplodia*. All these diseases are se in Travancore—the first three only in mild forms of a [illegible] nature, but the last in a more serious form over a wider [illegible] root disease has been in the country for well-nigh over [illegible] century; but the people took no notice of it, and the Durbar had no knowledge of it till 1897, in which year some of the owners of affected palms presented a memorial inviting the attention of the Durbar to the serious nature of the disease and praying for help. At first the Durbar did not think that the matter was a very serious one; but when the authorities fully realized the seriousness of the situation they applied to the Government of India for the services of a mycologist to investigate the disease, and accordingly Dr. E. J. Butler, Imperial Mycologist, India, was deputed for the work in 1907. He went over to Travancore, investigated the disease, submitted a report to the Durbar, and published an account of his investigations in Bulletin No. 9 of the Agricultural Research Institute, Pusa. Most of the suggestions of Dr. Butler, such as segregation of infected trees in isolated areas, propagation of disease-resistant varieties of the palm, improving the general health of the palm by better cultivation and manuring, etc., have been given effect to, in the result that the spread of the disease has been arrested and a substantial improvement in the general condition of the palms in the infected areas has been effected. But the most important suggestion of Dr. Butler, namely, destruction of all infected material, has not yet been put into practice on account of the serious objections of coconut cultivators. The coconut palm and the cow are looked upon by Travancore Hindus with a certain amount of sacredness. The name "Devavriksham" is a sufficient indication of this fact as far as the palm is concerned. On religious grounds, therefore, the cultivators object to the destruction of the palm. They also object to it on sentimental grounds. A man who has planted and nursed a palm cannot brook the idea of killing it. Destruction is objected to on economic grounds as well. A diseased palm does [illegible] die all at once. It lingers on for five to six years, and during [illegible] period it continues to yield some nuts, though greatly diminished [illegible] size and number, till the very last stage, and the [illegible] prepared to lose the income, however small it be.

from his diseased palm. The last and the most serious objection is based on reasoning from the analogy of human diseases. What the cultivators say is that a plant suffering from a disease ought to be cured as human patients are and not to be summarily disposed of by destroying it. There is no use in arguing with people of this nature. They will never be convinced of the necessity of such radical cure as the destruction of all infected material for the eradication of this deadly disease and for saving the otherwise prosperous coconut industry of the country. Persuasion has been tried and has failed, and the only course left open is compulsion. The Durbar is convinced of the necessity of legislating on the subject and action is being taken in the Legislative Council.

Great industrial possibilities.

The coconut palm supports a large portion of the population of Travancore. Besides those actually engaged in the cultivation of the palm, the industries connected with its produce give work to more than 150,000 persons. The most important of these industries is the manufacture of coir yarn from the coconut husk. It is carried on as a cottage industry by the people living on the coast and on the sides of lagoons and backwaters. Green husk is soaked in water for about six months, is then taken out, beaten with a wooden flail, and manipulated by hand to separate the fibre from other tissues, and the fibre is thoroughly cleaned also by hand and twisted into yarn with the help of a small hand-wheel. The finished yarn is graded according to its fineness and colour and sold to merchants. The industry is practically in the hands of women of the poorer classes. The husk is generally bought and soaked by petty merchants, and the soaked husk is sold by them in small quantities to women. A woman usually buys about 2 annas worth of soaked husk every morning, and by evening she prepares yarn and sells it back to the merchant for about 4 annas, thus making a profit of 2 annas. Before the outbreak of the present war the price of green husk was something like Rs. 10 per 1,000, and the cost of labour and other charges for soaking and preparing yarn varied from Rs. 15 to Rs. 2[illegible] The husk of 1,000 nuts would yield 200 lb. of yarn, the price [illegible] which is ravancore before the war was Rs. 30 to Rs. 35. This was the price which yarn was being sold by petty merchants to wholesale porters. The former were thus making a profit of Rs. 5 to Rs. 10 an investment of Rs. 20 to Rs. 25. The wholesale merchants, ostly Europeans, who exported the article to foreign countries, must ve been making considerably larger profits. The yarn that went those countries was being used for the manufacture of cordage, atting, rugs, and carpets, and the manufacturers must have also een making very large profits from their business. Here is an indus- y which is capable of yielding enormous profit, and owing to the ck of industrial spirit in the country the lion's share of it goes to the ore enterprising nations of the world. Travancore exports annually bout Rs. 57,00,000 worth of coir, and if all this coir had been manu- ctured into finished articles in the country itself, she would have obably got another Rs. 57,00,000. This is indeed a serious loss the country, but still greater is the loss that accrues from the xport of *copra*, oil, and nuts. The aggregate value of the annual ex- ort trade in these articles before the war was about Rs. 1,08,00,000. f the manufacture of margarine, soaps, and candles out of these rticles, which is now being carried on in foreign countries, had been ndertaken in the land of the palm itself, another crore of rupees ould have easily been added annually to the income of its people. ndia, as a whole, is backward in industrialism, and Travancore is ven more so than India. Even in this war time, when every part f the British Empire exhibits an unusual awakening in matters ndustrial, Travancore continues in the same old groove. The war as hit the country very hard. Owing to the shortage of tonnage ts coconut products cannot be sent out. The price of nuts has allen to Rs. 20 per 1,000, while before the war it was as high as Rs. 65 o Rs. 70, and even at the reduced price there is no one to buy them. If things continue like this for a few years more, which God forbid, the much talked of prosperity of Travancore will have to make way for a chronic state of poverty. Such a catastrophe could certainly be warded off if the people would only wake up from their slumber, realize the immense possibilities that exist in their country for the development of coconut industries, and go forward with a dash, start these industries boldly, and invest their money in them having regard to their own interests and the interests of the country. But I doubt very much whether they will do it. At any rate they have not begun to do it, and in the meanwhile other people have come forward to take their place. It has been announced in newspapers lately that that enterprising firm, the pioneers of gigantic industrial undertakings in India, Messrs. Tata & Sons, have decided to establish a factory at Cochin for the manufacture of margarine and other articles out of coconut oil. When this project becomes an accomplished fact, which I hope will be very soon, the firm ought to be in a position to buy up a large portion of the coconuts produced in Travancore, Cochin, and Malabar, and afford relief to the coconut cultivators of these territories from the hardship which they now suffer on account of the want of shipping facilities. The people of Travancore have received the announcement of Messrs. Tata & Sons with universal joy, and are eagerly looking forward to its early fulfilment.

Selected Articles.

THE SOURCES OF THE MILK SUPPLY OF POONA CITY.*

BY

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THE improvement of the supply of milk to Indian cities has been a subject of very serious consideration in many parts of India in recent years, and nowhere more than in the Bombay Presidency. The matter was brought into prominence by a paper on the subject which I read at the Agricultural Conference in Poona in 1913, in which I gave the results of a careful examination of the milk supply of Poona City in that year. This showed that the milk available was insufficient in amount, was exceedingly poor in quality, and was to a very large extent produced under highly insanitary conditions.

Shortly after this the matter was considered on a more general basis by a committee presided over by Mr. G. F. Keatinge. The report of this committee confirmed the essential conclusions of my paper of the previous year, and made a large number of recommendations. In general while emphasizing the extreme complication of the problem of city milk supply in Western India, they considered that it would ultimately be solved by the organization of supply from cultivators and others keeping cows and [illegible] under natural conditions at a distance (often at a far dist[illegible]) the town and by the improvement of transport which [illegible]

* A lecture delivered before the Deccan Agricultural Ass[illegible]

possible to place such milk on the market in good condition. Lack of knowledge of the difficulties which were likely to arise led, however, the committee to recommend that a single large city should be selected, the whole question of its milk supply investigated, and the most suitable directions for its improvement worked out at the cost of Government. The beginnings have now been made of such an investigation in the case of Poona, and I wish to place before you some of the data which we have obtained. I may say at once that I do not yet see the way clearly in which all the difficulties will be removed, but I always feel that to know these difficulties is the first step towards meeting them.

The first weakness of the present milk supply in nearly all cases is its deficiency in quantity. In Poona, in 1913, I found that the total milk available daily from all sources was under four ounces daily per head of population. This small supply, to a population which would use milk if it could get it, means a very dear supply and a very much adulterated supply. In fact, any attempt to stop adulteration, without at the same time increasing the quantity available, increases the dearness of the milk and hence the power of the people to get it. The price of pure milk in Poona City was already 50 per cent. higher than that customary in cities in England before the war, and it was at the same time difficult to obtain. This high price occurs in a country where the average resources of the people are very much smaller than in Europe.

The first problem, therefore, was to increase the supply of milk. At present there are three sources from which milk is obtained. In Poona 78 per cent. of the total is got from animals kept inside the city, either by professional *gowalis* as a business or by private householders for their own use. The second source of supply consists of milk brought in from the surrounding villages where milch animals are kept in part by professional *gowalis*, and in part by cultivators as a secondary source of income. In Poona this comprises practically all the remainder of the supply. The third source, which has been negligible in the past in the case of Poona, is the organization of the supply of milk from more distant villages where it is produced by cultivators, under cheap and natural conditions, but where at present the difficulty of getting it to market prevents it being taken to the cities.

Of these sources of milk, the first, I feel, cannot be materially increased, owing to the increasing population in the city. Nor is it desirable that it should be increased. The milch animals are usually kept under unnatural conditions, nearly always insanitary, and the milk must necessarily from the nature of the case be dear. With regard to the second source of supply, namely, the surrounding villages, the organization of this supply is already being taken up by co-operative societies and others. If it pays to produce milk for city use in these villages the organization is not a very difficult matter.

The third source of supply has not, however, been exploited at all. And yet it was known that milk was produced at what seemed extraordinarily cheap prices at places little beyond the present sources of supply. I therefore decided to take four areas, all accessible from Poona by roads or rail, and all beyond the present range of supply, and investigate, village by village, (1) what is the present possible supply of milk; (2) at what price it can be purchased in the villages both in the cold and the hot weather; (3) the likelihood of the increase in the supply if a sure market was obtained; (4) the quality of the milk which could be available. In doing this I have to thank my assistant Mr. V. G. Patwardhan for his devoted work in collecting data in all these areas, and Mr. S. V. Shevde of Talegaon (and Mr. Patwardhan working together) for a very exhaustive examination of the situation and its possibilities in his own area.

The four areas which were selected as places where good milch cattle are or have been kept were as follows:—

(1) The group of villages at the foot of Singarh, situated from seven to fourteen miles to the south of Poona and connected to the city by a good and fairly level road.

(2) The group of villages near Khed Shivapur. This village is situated fifteen miles due south of Poona by a first class road, but between the two places there is the Katraj Ghat.

(3) The group of villages in the valley of the Indrayani river round the small pilgrim centre of Alandi. This lies twelve miles almost due north of Poona with which it is connected by a good road.

(4) The group of villages round Talegaon station on the G. I. P. Railway, connected with Poona in about an hour by a frequent and excellent service of trains.

The first conclusions which appeared from our inquiries were—

(*a*) that in recent years the milch cattle in all these centres appear to have been decreasing rapidly;

(*b*) that the relatively low price of milk is due to a lack of demand only, for a comparatively small local demand, as at Alandi, raised the price to a figure approaching that in Poona City;

(*c*) that the milk capable of being obtained under present circumstances was an exceedingly variable one, and in many cases almost disappears in the hot weather;

(*d*) that the milch animals kept yield extremely little milk per head.

The decrease in the number of milch cattle seems to be very considerable, when our figures are compared with the last cattle census in 1915, in all these areas. It is, of course, possible that (owing to the well-known reluctance of the people in Deccan villages to give particulars regarding their cattle) one or other of the enumerations is not entirely correct, but I feel that this can hardly account for all the difference. In the Singarh area the decrease in milch cattle (cows and buffaloes) in five groups of villages (*Mouzas*) amounted to 37 per cent.; in the Khed Shivapur area it reached 26 per cent. for sixteen groups of villages. The number may in both these cases have been affected by the fact that the investigation was done at the height of the hot weather, but the difference, I think, is not very material. This cause was not, however, dominant in the Alandi area, where the decrease was 37 per cent., in spite of the enumeration being done in the rainy season. At the Talegaon villages the decrease appears to be about 29 per cent.

This decrease is alarming, and, making every discount [illegible] inclined to think it is real. It is attributed by the people [illegible] to various causes, notably to the increased stringency [illegible] regulations, to a shortness in the amount of fodder in the [illegible] of forest grazing, and to absence of ready money among the vill[illegible]. It has undoubtedly been aggravated by the ravages of rinderpest in recent years, which have caused very great losses indeed, and also to serious outbreaks of foot-and-mouth disease. The investigation of the causes of this reduction in the milch cattle demands, however, another and special study.

The price of pure milk in the areas in which there is no special local demand varies from sixteen to eighteen pounds per rupee. For this amount the morning milk would be brought to a depôt in one of the villages, provided the distance is not more than two or three miles. This might also be done with the evening milk, but I am not quite sure. I think, too, that for this price with a shrewd purchaser, unadulterated milk could be secured. The higher price would have to be paid, of course, in the hot weather.

In one of the centres examined, Alandi, there is a local demand for milk chiefly for pilgrim visitors to the place. This demand, variable and uncertain as it is, raises the local price of milk to ten to twelve pounds per rupee—a figure not much below that which it fetches in Poona. This occurs in spite of the fact that the Indrayani valley in which Alandi lies is an excellent place for cattle and that there is a very large number of milking animals in the neighbourhood.

One of the biggest difficulties met with is, however, the extreme variability of the supply. In the months from September to January (cold weather) there is often enough spare milk to form the basis of a supply, while in the remaining months of the year there is little or none to be had. I will illustrate this point from my figures. In a group of villages round Singarh the amount of milk available partly in the cold weather for sale runs about [illegible] fifty gallons: in the same group in the hot weather there [illegible] not more than ten gallons per day. In another area [illegible] round Khed Shivapur, in the cold weather the [illegible] available for sale amounts to about 140 gallons daily. In the [illegible] the year this gradually sinks to less than 30 gallons. The [illegible] difficulty is found everywhere, and I suppose will [illegible] until fodder is more largely grown by the people and preserved [illegible] silage or in some other manner.

The yield per head of the milch animals in a Deccan village appears to be astonishingly small. According to the people it [illegible] amounts to about two pounds per day per milking animal and [illegible] to one pound per day in the hot weather. It must be remembered, however, that in a large number of cases, particularly among [illegible] this amount is obtained after the calf has been fed, and where [illegible] breeding of a good working bullock is a matter of [illegible] importance this may well take a very large share of the [illegible] produced.

In some respects, therefore, the results of our investigation [illegible] the present milk possibilities of a number of likely areas near Poona are disappointing. They show that at present the amount of milk available is small, and, that being the case, the price very [illegible] rises to a figure which is no use for the supply of Poona. They [illegible] also that the yield of milk from existing animals is very small [illegible] that the difference between the quantity in different parts of the year is so great that the milk available almost disappears in [illegible] hot weather. The question, however, at once arises as to how far the quantity available is likely to increase, and the keeping of milch cattle can be taken up on a larger scale and on a more satisfactory basis if a regular and certain market is provided.

I may, at once, say that, except at Alandi where there is a certain local demand, the people themselves say that, provided a ready and constant sale is guaranteed, they will go in for more milch animals and be able and ready to provide more milk at the present prices. In some villages in the neighbourhood of Talegaon, the people were particularly emphatic. "If you want the milk," said they, "we will provide it, but get the business started."

The matter is, I think, ripe for experiment, and in one case, that of Talegaon, a certain amount of experiment has been made by my friend Mr. S. V. Shevde, and I propose now to describe what

[h]as been [do]ne there, the difficulties met with, and the way [in which] [th]e matte[r] may possibly be brought into practice on a consider[a]ble scale. I want to give a perfectly frank statement on the [s]ubject.

The experiment in question was started in August 1917 from [a] village which was stated to be able to give 100 pounds of milk per [d]ay, and the people were asked to bring the morning's milk to the village *chavadi*. No check was possible on adulteration at first, [b]ut a warning was given that adulteration would wreck the scheme. The village chosen was about two miles from the depôt near Talegaon station by a short cut or three miles by a regular road, and the [m]ilk was brought to the depôt between 9-30 and 10-30 A.M. at a [c]ost of two annas per coolie employed.

For the first few days the milk was brought in good condition at 16 pounds per rupee and cash was paid. Then the first difficulty [ar]ose in that the producers began to mix fresh milk with the milk from the previous night's milking. It was quickly found that if this was done the combined milk quickly became sour and was unfit for sending to Poona, but the cultivators took the stand that they could only continue to give us the morning's milk if we bought also the milk of the previous evening. This meant the organization of purchase of the evening milk also; a more difficult matter, as, at night, it was more costly to carry to the depôt, requiring two coolies instead of one and so doubling the carrying charges.

The next difficulty was that the milk which had been quite good at first rapidly began to be adulterated largely with water. So far the provision of a lactometer and its use by the milk collector has met this difficulty. The people, in fact, having once tasted the advantages of a regular sale practically at their doors, did not wish to risk their market and have brought decent milk again. So far the average fat content of the morning's milk is 7·2, and of the evening milk is 5·1. This is likely to be always the case [as there] can be better supervision in the morning.

The regularity of supply has been perfect, showin[g] [...] matter the cultivators can be depended on.

The next difficulty has been the keeping of the milk after receipt. So far the night milk has been simply placed in open vessels in a cool and airy place, and has been despatched to Poona by the train reaching there at 5-30 A.M. It is distributed before 8-30 A.M. Thus the milk, taken from the cow between 6 and 8 P.M., is delivered in Poona exactly twelve hours later. Even in the months between August and November, 1917, there has been some difficulty about it going sour with no greater precautions than those indicated. About three times a month it has been slightly sour, and this is, of course, fatal. It is evident that the evening milk cannot be delivered in Poona from Talegaon unless some form of artificial cooling is used or unless the milk is pasteurised.

The difficulty is greater with the morning milk. This arrived at the depôt at about 10-30 A.M., the cows having been milked at 7 A.M. and the milk having been carried in the sun. It reaches Poona at 12-45 P.M. and is delivered by about 2 P.M., though it is not usually used until the late afternoon. In this case, the danger of going sour was considerable, and it quickly became evident that unless a cooler at least, and possibly a pasteuriser, is installed at Talegaon a trade in the morning milk is impossible.

This involves a greater expenditure at Talegaon for preserving the milk. Luckily ample well water is available for cooling and is always fairly cool. Well water rarely is above 70° F. and often considerably below this, and with its use it will be possible to keep the milk, both evening and morning, at a temperature which will prevent it going sour. This is the next stage of our experiment. If found not sufficient, it will be necessary to instal a pasteuriser and this will mean considerably greater initial cost.*

In general our inquiries at Talegaon show as follows. The conclusions would probably be the same for many of the stations in the large grass areas between Poona and Lonavla.

(1) Talegaon is a good centre for milk supply, and with a little organization about 1,000 pounds of milk would be available in the

* A pasteuriser has now been put in.—(H. H. M.)

cold weather, and perhaps half this amount in the hot weather within a distance of not more than four miles of a depôt near Talegaon station. The price will be from 15 to 16 pounds per rupee at the collection centres.

(2) A constant demand will lead to a fairly rapid increase in the number of milch animals kept and to better feeding of the animals, provided cash is paid for milk.

(3) The organization of the supply to Poona will involve treatment of the milk at least by cooling and probably pasteurising, as arrangements cannot be made for its certain delivery in Poona much less than twelve hours after milking.

(4) The disposal of the milk in Poona in the morning presents few difficulties; that arriving in the city in the afternoon is more difficult but can, I think, be got over.

(5) The organization of this supply would mean an initial expenditure of about Rs. 2,500, and if 500 pounds of milk a day were supplied, it should yield a profit of from Rs. 100 to Rs. 250 per month, without counting interest on the investment.

Other difficulties would arise undoubtedly, such as the demand falling off when Poona is plague-infected, and the like. But I think that the scheme outlined gives a sufficient chance of success to be gone on with, and I feel that there is every chance of the supply growing to an extent which we can hardly conceive at present.

What may be done at Talegaon may also be done probably at a large number of other centres situated in an equally favourable or more favourable position. I have already heard that similar schemes have already been mooted at other stations near Poona. If these work out, we shall have taken a step in the same direction as has been followed in practically all large towns in western countries, where the supply of milk from considerable distances by collection from genuine farmers, has gradually replaced the supply from town *gowalis*, which was almost universal a [illegible] ago.

Our experiments have not gone so far in the [illegible] where our inquiries have been made as at Talegaon [illegible] seems reason to suppose that milk can also be successfully supplied by road where there are good dairy centres or centres with good dairy possibilities. Such a one is Khed Shivapur and the neighbourhood. Here the organization would probably have to be different, though I speak with caution, as sufficient experiment has not yet been made. The real difficulty in these road journeys is the rapid transit to the city, and the only means of effecting this seems to be by motor, the pasteurising being carried on in the city. To do this would need a very large supply—larger than seems to be available at present. But I prefer to leave the discussion of this matter until our experiments have gone further.

On the whole, therefore, our inquiries show that the supply of milk to cities from outside is beset by difficulties which do not occur elsewhere in the same form. The fundamental difficulty is probably the low yield of the animals, and the fact that the people trust to casual supplies of fodder and have not learnt the use of silage or its equivalent. But there seems reason to suppose that these difficulties can be got over, and once the movement is started, it will, I feel, get constantly increasing momentum. Once the supply of milk is adequate in the city, I believe the difficulties of regulation of quality and securing of a sanitary supply will solve themselves.*

* Since the above was written, a regular organized supply is being obtained from Talegaon, where a pasteuriser has been installed, and it is hoped to reach 700 pounds per day in the cold weather of 1918-19. If as successful as promises to be the case, I shall hope to give an account of this experiment and its difficulties later on.—(H. H. M.)

IMPROVEMENT OF COFFEE BY SEED SELECTION AND HYBRIDIZATION.*

BY

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Ever since Mr. Cameron called attention to the possibilities of it in his report on a visit to Coorg in 1899, a certain amount of work has been done along the lines of hybridizing coffee to raise a new strain which will bear more heavily than the ordinary *arabica* and be more disease-resistant. A fair measure of success has been attained in several places, notably in South Mysore by Mr. Crawford, and by Mr. Hamilton at Chundrapore, and by Mr. Jackson in South Coorg, who has succeeded in raising on a large scale a very satisfactory hybrid which comes true to seed. It is to be hoped that before long this seed will be on the market as soon as Mr. Jackson has supplied his own requirements. Again, at Doddengooda, in South Mysore, Mr. Kent has got established a good strain of coffee which may or may not be a true hybrid : its history is unfortunately not known with accuracy.

The work of making hybrids is long and tedious and scarcely suited to estate conditions, however, and I still hope some day to see this work being done by an Economic Botanist on a special coffee garden. As I have said before, it would pay coffee planters to establish such a station and an expert even though they would be working more or less for posterity.

What I wish to speak of to-day, however, is a simpler matter which could, and ought, to be undertaken by every coffee planter.

* Speech delivered at the Coffee Planters' Conference held at Mysore in July, 1918.

namely, the selection of seed. A tremendous improvement can be made in the strain of any plant by persistent seed selection, and many of our economic crops are being annually improved by this method alone.

The starting point is what everybody has, "the best tree on the estate." I am constantly shown this in the course of my tours, but I am seldom or never shown what I want to see—the fields of coffee which have been planted with plants raised from the seed of this tree. Indeed the method of taking coffee seed for planting nurseries, which I see going on, is as a rule a most haphazard one. There is no selection about it and in most cases no one can tell from which trees the seed came, not always even which field. This system is all wrong from start to finish, and in my opinion it accounts to a very considerable extent for the deterioration of the strain of coffee which has undoubtedly taken place in some districts.

As I say, the starting point for selection work is the "best tree on the estate," or the best several trees, judged by their yield under all circumstances, even in bad climatic seasons, the shape and habit of the bush, its freedom from diseases and its resistance to leaf disease and scale insects. Having chosen a few trees like this the next thing to do is to cut out the coffee trees round them, to give them ample space, light, and air, and then to make arrangements for netting them when they are in flower. To do this four stout posts should be put in the ground at the corners of a fourteen-foot square, each post about ten feet high, and a mosquito net made to fit over them so as to completely enclose the whole bush. It is a good plan to sew a valence of stout cloth round the bottom edge of the net which can be laid on the ground and have earth piled on it to keep the net steady and prevent it being blown about by the wind.

The blossom set under this net must be self-fertilized, which is an important point. If allowed to set in the open one has no control over the pollen used, and it may come from the worst tree on the estate. Seed self-fertilized will come true to a large extent and reproduce the characters of the parent tree.

This procedure will no doubt decrease the normal crop of the tree but this does not really matter, enough seed will usually be tained t. plant up a fair-sized nursery. It is possible that the introduction of bees under the net might help the pollination and increase the crop. This has been tried, but I understand that the bees did nothing but fly round and round the net trying to escape. This may have been because the net was not big enough, and more observations on the point are required.

As soon as the fruit is set the net may be removed and stored for future use. Work should then be begun on the preparation of the nursery which is to receive the seed, and this nursery should be made with all the skill and experience at the command of the planter. It is a special nursery worth infinite trouble and expense to ensure its success. The berries should be gathered when as ripe as possible and pulped by hand and only the best seeds chosen. Peaberry need not be rejected, as peaberry is an accident and not an inherited character.

The nursery plants should be spaced widely and most carefully attended to and sprayed with Bordeaux Mixture, if necessary, to protect them from attacks of leaf disease. When ready to plant out, a second selection should be made, and this second selection is most important. Only the very best plant should be put out. A weakly plant or one of bad shape should be rejected as should even doubtful plants. In my opinion it is a very good nursery indeed from which 75 per cent. of the plants can be put out. It often happens that on looking at a new clearing I see a corner which is very poor compared with the rest, and I am told that it was "planted with the tail-end of the nursery." Well, it does not pay to plant out that tail-end of the nursery and it is better to leave a portion unplanted for a year and keep it under a green dressing crop than to put out poor plants.

The next stage is to select the best three or four bushes from the clearing planted from the first selected seed as soon as they come into bearing and to repeat the process. By this means each clearing would improve in strain and in course of time a ... strain of coffee would be built up. I am inclined to ... this is what has happened in the case of Mr. K... accidentally. The seed was isolated in a village ...

a selected strain has been established which is as good as hybrid.

I am convinced that a process of selection of this sort over period of 10–20 years would make a great improvement in the yield and welfare of the coffee estates, and that it would be a better plan, rejuvenation than trying to introduce new seed from other countries which will not be selected seed and will need acclimatization and subsequent selection in any case. On any estate supplies put out should be grown from selected seed and special nurseries.

Experiments with seed selection have been carried out for years by the Department of Agriculture in the Dutch East Indies. In these experiments the seeds from each selected tree are sown and cultivated separately, and the growth and production of the different lots are compared amongst themselves, and the tree which gives the most vigorous and productive descendants is chosen to provide seed for the future. In many cases it has been found possible by this method of seed selection to separate a large number of varieties which have been proved constant by successive sowings. *Coffea arabica* has in this way been made to yield not less than fourteen such varieties, and I am inclined to think that the Doddengooda so-called hybrid is not a hybrid at all but a variety of this nature.

That the best way to improve the strain of South Indian coffee lies along lines of hybridization and selection, I am convinced. The President of the Botanical Section of the British Association in his opening address at the last meeting of that body which was held, said: "The improvement of the plant from an economic point of view implies the co-operation of the botanist and the plant-breeder. The student of experimental genetics by directing his work to plants of economic value is able, with the help of the resources of agriculture and horticulture, to produce forms of greater economic value, kinds best suited to different localities and ranges of climate, those most immune to disease, and of the highest food value. Let the practical men formulate the ideal and then let the scientist be invited to supply it. Much valuable work has been done on these es, but there is still plenty of scope for the organized Mendelian study of plants of economic importance."

The production of new varieties of any crop is a sure method of increasing the yield. Soil conditions are only capable of being modified to a certain very limited extent, and if the plant-breeder and agricultural chemist can co-operate to produce a new type of plant better adapted to the local conditions it is obvious that an increase in crop will result.

At Dubarri, Mr. A. H. Jackson has produced a type of coffee plant which is fertile and comes true to seed, and the consequence is that the seed can be depended upon to provide nurseries for new clearings and new estates. This type is a true hybrid and a vigorous healthy type of *arabica* coffee, apparently disease-resistant to a high degree, and one which comes into bearing early and which gives a high yield of a good sample.

The result may be judged from the fact that some of the hybrid trees planted in a clearing purposely placed under adverse conditions of soils, shade, and facing, bore in their second year at the rate of 13¾ cwt. an acre, and more in some cases, and that they held and ripened this crop without shedding any primaries. They have now given three big crops without any sign of dying back. A sample of the bean has been very favourably reported on in England and the experiment has so far proved a great success.

Last September the final step in this experiment was begun, namely, the planting out of this hybrid on an estate scale. Last week I had the pleasure of inspecting the first clearing of this hybrid, at Malamby, some 23 acres in extent. It is planted in good soil and under ordinary estate conditions, and the clearing is an object-lesson in what a vigorous strain of coffee will do. Though only just a year old the large majority of the trees are three feet six inches in height and have 13 and 14 pairs of primaries closely set together. The plants are very healthy and are growing vigorously, and there were no failures from drought. The plants will have to be topped when less than 18 months out and will bear a crop in their second year and a good crop too, surely a record for arabica coffee.

The type is very even indeed, the plants in the row being alike as peas in a pod. In fact there is less difference to be seen between plant and plant than in an ordinary *arabica* clearing. There is little to show that the plant is a hybrid except its remarkable vigorous growth and a slight crinkle to the leaf.

This long experiment of Mr. Jackson's has now reached the last stage. It only remains to send home a shipment of the coffee from this plant and let it stand the test of competition in the open market with other South Indian coffees of good mark. This test is looked forward to with the utmost confidence, and I would once more impress upon doubters that they should visit Malamby and see for themselves what seed selection and hybridization of coffee can result in.

THE PROMOTION OF SCIENTIFIC AGRICULTURE.*

WHEN, in his recent speech at Wolverhampton, the Prime inister spoke of the need for promoting scientific agriculture, touched upon a subject of great national importance, and it may profitable to attempt to give significance to his words. As was inted out in the last issue of *Nature*, it may be that what r. Lloyd George had in mind was merely the extended use of rtificial manures, the discovery and methods of use of which were ndoubtedly scientific discoveries of the first magnitude, with which e name of Lawes and his experimental station at Rothamsted will ver be honourably associated. But we should like to think that the ssages in the speech to which attention was directed are evidence hat the Prime Minister has advanced to a position which few of his olitical forbears ever reached, namely, that progress in the arts nd industries is indissolubly bound up with the progress of science ; nd science in this connection should not be limited to the " natural " ciences. The application of the scientific method to technical problems may well be as potent an element in progress as the doption of the results of scientific research properly so-called. The field experiment in agriculture may not be research, but it is futile as an *experiment* unless it is conducted under the conditions and interpreted with the precautions which science dictates.

If, then, the Prime Minister has resolved that agriculture shall benefit from science, his first task is to take such measures as are likely to be fruitful of results. It will not suffice merely to provide unlimited funds even on the scale of a " day's cost of the war," at the same time a well-considered plan of operations has framed. Scientific research in agriculture in the past has

* Reprinted from *Nature*, dated 5th December, 1918.

from a failure to attract a sufficient number of men of first-class scientific talent. This failure has been largely due to the fact that agricultural research offered no career. Not only were such posts as were available inadequately paid, but essential needs, such as well-equipped laboratories with adequate provision for maintenance had not been provided.

In the forefront, therefore, of the measures that should be taken to link together practical agriculture and science should be placed the recruitment of the best scientific talent that the country can provide, and this can be secured only by providing suitable openings with reasonable prospects of advancement for the best of the graduates in science turned out annually by the universities. Programmes of research avail nothing in the absence of competent men to carry them out. We should like to see a scheme inaugurated under which promising graduates in science would be attracted to the study of the agricultural sciences by the provision of special fellowships under a guarantee that a certain number would eventually be selected for permanent posts carrying adequate salaries.

It is true that in the past most of the great discoveries have been made by men actuated merely by a love of knowledge for its own sake, and no doubt the future will not differ from the past in this respect; but the real point is that, if anything is to be accomplished by State action, an appeal must be made to the motives by which the majority of men are actuated in choosing their life career. There can be no question that if emoluments were placed upon a basis which would enable workers to live in reasonable comfort, while prospects of advancement were also improved, the fruits of the vineyard would be ample. Agriculture and horticulture are still in the main ruled by empiricism and tradition, and while it is true that many of the more recent advances in science go to confirm the wisdom of the ancients, no one can doubt that we are still far from possible ends in many directions. Scientific methods of plant-breeding alone are capable of indefinite expansion. Scientific methods of controlling plant diseases can be foreshadowed with considerable confidence. The crop-bearing capacity of the soil may, as Mr. Lloyd George suggested, be increased by scientific ans, and in the region of diseases of live-stock the possibilities progress have scarcely been explored.

The Prime Minister's declaration should not be forgotten. agriculturists are alive to their interests, they will see that it is t allowed to lapse into the oblivion which so ruthlessly overelms many of the platform promises of politicians.

PLANT GROWTH AND REPRODUCTION.*

It is well known that in many plants there is a well-marked antagonism between growth and reproduction. This is clearly seen in the case of many fruit trees where the conditions which lead to active vegetative growth may be inimical to the reproductive processes. In such cases the reduction of vegetative growth as by root pruning, may bring about vigorous flower and fruit production. The study of the effect of external conditions on these two processes, growth and reproduction, is obviously of great importance. In the case of the higher plants, however, the difficulty of investigating such a problem is increased by the close connection under ordinary conditions of the various external factors; it is thus very difficult to alter one factor without altering others at the same time. In the case of algæ and fungi which can be grown in the laboratory under artificial conditions that can be easily varied at will, the difficulties are not so great, and it is not surprising that in this field of work our knowledge is mostly based on experiments with the lower organisms. The art of growing micro-organisms, such as bacteria, fungi and also algæ, in pure culture, has been carried to a high pitch of perfection, but since the growth of bacteria and fungi takes place within such wide limits and under a wide range of conditions, the analytic study of environmental factors has been largely neglected in the development of pure-culture methods. Some bacterial parasites of animals are markedly sensitive to temperature conditions, but the majority of fungi will grow within a wide range of temperature, so the effect of temperature on the growth of fungi has not been fully studied. Again it is convenient in culture work to grow fungi in tubes plugged with cotton-wool, *i.e.*, under conditions in which gaseous exchange must be reduced to a low

* Reproduced from *Scientific American Supplement*, No. 2246, dated 18th January, 1919.

...wel. Yet since most fungi tolerate readily such conditions, the ...fect of ...eration on the growth of fungi has been neg...ted. A certain amount of analytic work with the help ... synthetic media was carried out by earlier workers, such ... Pasteur and Raulin, and later by Winogradsky and ...eijerinck. In 1896 Klebs published the first of his series ... papers on the effect of external conditions on algae and fungi ...own in pure culture. Klebs did not confine himself to the effect ... such conditions on growth, but he studied the effect of external ...nditions on reproduction also. Klebs put forward the view ...at growth and reproduction are processes which depend upon ...fferent conditions, and that as long as the conditions favourable ...r growth are present, reproduction in the lower organisms does ...t occur. Klebs brought out also a point of great importance, that ...e conditions suitable for reproduction are more restricted than ...ose for growth, so that reproduction is liable to be inhibited by ...o high or too low intensity of some factor.

It is well known to mycologists and plant pathologists that ...ough there is little difficulty in growing most fungi in pure culture, ...e production of reproductive organs by fungi under these conditions ... quite another matter. Anything which will enable one to control ...e reproductive processes of such fungi is thus not only of great ...ysiological interest, but of considerable practical importance in ...nt pathology. Reference may thus be made in this article to a ...luable paper—not of most recent date, but very generally over...oked—by G. H. Coons on the factors involved in the growth and ...cnidium formation of *Plenodomus fuscomaculans* ("Journ. Agric. ...search," V, 713–769, 1916), in which the relation of growth and ...roduction to external conditions is very carefully studied. The ...ngus in question is one of the Sphæropsidaceæ and is parasitic on ...e apple.

It was found that in agreement with the dictum of Klebs the... ...s a wider range of conditions suitable for growth than for ...ction. A small amount of growth will take place in ... ...ter (sp. cond. 2×10^6) in vessels of resistance glass ... ...owth is certainly very surprising. The number of species used for inoculation was not more than fifty, so the growth observed could not be explained by transference of organic material from the spores. The salts required for development under these conditions, and in ordinary distilled water, were no doubt obtained from the glass, but the source of nitrogen, and especially of carbon, is obscure; there is the possibility, first suggested by Elfving, that volatile substances may be absorbed from the laboratory air. It is interesting to note that while in conductivity water there was a just perceptible growth in ordinary distilled water the growth was not only better, but a few pycnidia were actually produced. Under the conditions of experiment conductivity water is the lower limit for growth, but "distilled water" the limit for reproduction. As Coons points out, the sensitiveness to extremely small quantities of salts renders the problem of determining the necessary elements for this fungus almost insoluble with our present technique.

Up to a certain limit, possibly up to M-50, increase in concentration of the food supply increases reproduction; after that point increase of food supply retards and finally inhibits reproduction. The organism was found to be sensitive to the reaction of the medium, and the different effect of different media was largely due to the reaction of medium not only at the start, but in later stages of growth. Many media, while having a favourable reaction at start, showed an unfavourable reaction later, with corresponding checking of growth. It was found that while growth can take place between the acid and alkali limits of +30 and −10 to phenolphthalein, yet reproduction is stopped by a reaction only slightly on the acid side of neutrality. Maize broth is a much better substratum than oat broth, but if the latter be acidified with an acid phosphate, or even hydrochloric acid, it becomes almost as good a medium as maize. The various laboratory media are rightly condemned as "rather purposeless, clumsy devices in which this organism is overfed." Progress can only be made by the use of synthetic media, and a large number of experiments were made with a medium containing in various proportions potassium dihydrogen phosphate, magnesium sulphate, maltose and asparagin. A solution containing these four substances in concentrations of M-100, M-500, M-100, M-500, respectively, was found o be an almost ideal culture medium for the growth and reproduction of this fungus; the pycnidium production was far higher than in any other medium. In this synthetic medium the inhibition of reproduction as a result of increasing or decreasing the carbohydrate or asparagin was very marked.

Light was found to be essential for reproduction though not for growth. The light need not be continuous, for a short exposure to strong diffuse light of cultures which are ready to produce pycnidia will allow, for a time, the production of these bodies in the dark. Abundant aeration was found to be essential, while transpiration was found to be a factor of only secondary importance.

The extremely interesting and important observation was made that the ***stimulus of light could be replaced by a few drops of hydrogen peroxide.*** This observation was extended, and it was shown that a number of other oxidizing agents, such as nitric acid, potassium permanganate, ferric chloride, would produce the same effect and cause the production of pycnidia in the dark. The view is put forward that among the parts of an organism there exists a strong competition for oxygen, and that under conditions which favour growth the available oxygen is all used for ordinary metabolic processes. If the food supply is reduced, as by transfer to media of lower concentrations or to distilled water, a "hunger-state" sets in and ordinary respiration is lowered. If the organism is now stimulated by light or by some oxidizing agent, oxidation of the richer cell materials, such as fat and protein, sets in, and a large amount of energy is set free. "This energy is used in re-shaping the reserve stuffs into complex protein bodies, the spores." By Prof. V. H. Blackman, Sc.D., F.R.S., Imperial College of Science and Technology, London (Plant Physiology Committee), in "Science Progress."

SEEDLING SUGARCANES.*

In his presidential address to the Royal Agricultural and Commercial Society of British Guiana, Professor J. B. Harrison, C.M.G., M.A., discussed the general outlook as regards seedling sugarcanes, with especial reference to their stability, and the manner in which their production is best undertaken. These remarks, embodying as they do the experience of one of the principal workers in this field of enquiry, extending over the whole period since the simultaneous discovery in the West Indies and in Java of the seminal fertility of the sugarcane, carry very great weight; they are accordingly here reproduced in order to extend the publicity given to them. Professor Harrison said:—

"In 1897 investigators generally were of the opinion that once a new variety of sugarcane was produced, that after its first period of excessive vegetative vigour had passed, its characteristics were fixed for all time. Soon after the cultivation of the new varieties had been extended over large areas, it became painfully evident to the majority of planters that their characteristics are not fixed, and that in many instances, characteristics which in the earlier years promised to make a variety of sugarcane of high value both in field and factory were the first to fail. This tendency towards senile degeneration renders it necessary to raise new varieties of seedling canes year after year, in the hope of having fairly good varieties available to replace others which may gradually fail.

"Experience has proved to us that it is very easy indeed to raise new varieties of sugarcanes which are of high promise as plant canes. It has further proved to us that it is relatively difficult to obtain sugarcanes capable of producing good crops as plant canes and as first ratoons; and that it is exceedingly difficult to produce

* Reprinted from *Agricultural News*, dated 21st September, 191[illegible]

rieties which can be relied on to give satisfactory crops of plant canes, first, second, and third ratoons. Few indeed of the enormous numbers of new varieties which are now raised each year in various parts of the tropics will do this, and the problem of getting good varieties for cultivation under the long-ratooning system necessitated here by our deficient labour-supply and dependence on hand, instead of on mechanical, cultivation, becomes an exceedingly difficult one. Elsewhere, with the exception of Cuba, sugarcanes are as a rule only cultivated as plants, or as plants and first ratoons. Hence as the best varieties raised in Barbados, Java, and Hawaii have been chosen for their suitability for short ratooning periods, it is rarely that a sugarcane suitable for our long-ratooning conditions can be imported from elsewhere.

"The most successful method we have tried here for raising new varieties of sugarcane of promise is based on the facts that a sugarcane for successful cultivation on our heavy clay soils must be of well-marked vegetative vigour, and that whilst the range of variation in the saccharine-content of seedling sugarcanes is very great, its relative sugar-content is a fairly fixed characteristic of any variety. We endeavour to raise as many seedlings as we can from varieties of proved vegetative vigour, and select from them those having both well-marked vegetative vigour and relatively high saccharine-content. By this method we raised from D.625 the seedlings D.118 and D.419, the areas under which have increased from 2 acres and 1 acre, respectively, for the crop of 1911-12, to 2,710 and 1,360 acres, respectively, for this year's reaping.

"We have been advised time after time to give up our proven methods and to confine our efforts towards raising canes by cross-fertilization. If we had in this colony sugarcanes of single parentage showing fixed characters and, through their purity of origin, having little or no tendency to mutation or sporting, that advice would be excellent. In India, and to a less extent in Java, sugarcane varieties of high purity of strain exist; and with these it is possible that by the application of Mendelian principles in raising seedlings new varieties of high value may be obtained. Up to the present this has not taken place.

"At the inception of the sugarcane breeding work here, Jenman was enthusiastic over the possibilities of raising new varieties of high promise by controlled methods of cross-fertilization, but in 1892-93 our hopes in that direction received a severe shock. Using a variety of sugarcane, the Kara-kara-wa cane, which our experience in three preceding years had shown to produce seedling canes having usually somewhat close resemblance to the parent variety, and placing it under conditions by which it was impossible for its arrow or flowering shoot to be either cross-fertilized by any other variety or fertilized by any other flower shoot of its own kind, we got seedling canes from the one arrow of 267 different sorts. The parent cane in its own seedling stage was hence possibly derived from fourteen diverse ancestral strains.

"Supposing, for example, that we take two kinds of sugarcane, one, X, having as ancestral kinds the varieties A,B,C,D,E and F and the other, Y, derived from its ancestors A,B,G,H,I and J, it is evident that 406 different combinations can arise from the interbreeding of the two kinds, instead of a single blend or cross, X × Y.

"By Mendelian segregation, the inheritable properties of this diverse progeny will fall into three groups. We do not know which properties are inherited; but assuming that the general characteristics as a whole are heritable, the segregation of the seedlings from the cross X and Y may give rise in the first generation to 1,218 *groups* of varieties.

"Now either X or Y, by interbreeding with its own kind, could produce only 15 × 3 groups or forty-five general strains of sugarcanes. The complexity introduced by the cross-fertilization of existent complex hybrids is well illustrated by this example.

"Up to 1902 we had not made any systematic attempt at raising canes of controlled parentage. We now do it as a matter of regular routine—not with any idea of getting seedlings having definite and desired characteristics, but as a means of greatly widening the range of their variation. We have complete proof of the success of the method in this line. Unfortunately, there is no chance in British Guiana of controlled cross-fertilization of the sugarcane proving short and certain way to success in the production of new varieties high saccharine value.

"Probably a more disappointing investigation has never been pursued than has been the search for improved varieties of sugarcane. There are now many stations at work at it in the tropics and sub-tropics, their results appear to be very similar, in the earlier years, working with natural varieties of sugarcane, several kinds of high promise are almost invariably obtained; in later years, when the mass of material for parental purposes has rapidly and enormously increased, the production of really good varieties appears to become increasingly difficult, and results satisfactory to both investigator and planter tend to be few and far between. It looks as though the good results arose from the unravelling of the complex ancestry of the natural varieties, whilst similar results from the retangling of the new strains thus obtained are comparatively rare, and are very elusive."

Those who are interested in the introduction of new seedling canes into their fields will, doubtless, in the light of these remarks, carefully consider the results which they are obtaining from their efforts. It will be observed that, in Professor Harrison's view, the work of finding promising seedlings is much more difficult when it is required to have canes that will ratoon well; when plant canes only are grown, the problem is relatively simple.

The question of the stability of seedling canes propagated by cuttings has long been under investigation. Some have held that these canes would prove stable, and indeed in the early days of the work this was the commonly accepted view: now, however, many are doubting this, and Professor Harrison appears to be amongst those who are convinced of the tendency towards early senile degeneracy on the part of these seedlings. It is observed that, in some districts where sugarcane is cultivated, there is a tendency to substitute one new seedling after another in the hope of obtaining ever-increasing yields. Where adequate records exist, it would be well to examine these carefully, in order to see whether the newly introduced varieties retain their productiveness in full degree, or whether they fall off, so that the substitution of successive new varieties merely serves to maintain the sugar production at a high level, but does not tend to raise that level to the extent that is hoped and desired. Now that it is the commonly accepted practice on the majority of West Indian sugar estates to weigh the canes which are delivered to the large factories, and seeing that in the factories continuous analyses are made of the juice obtained from these canes, there should be in existence some data whereby it may be possible to learn something definite concerning the stability or otherwise of seedling canes during the years subsequent to their introduction into cultivation on a large scale.

Still the fact remains that the continued production of new seedling canes is a matter of moment for the sugar industry. This work affords means of combating many of the forms of fungus diseases to which sugarcanes are liable, and it also affords the means of maintaining the level of production, even if it does not tend to raise the level so rapidly as was at one time hoped might be the case. It is therefore work essential for the well-being and development of the industry, and should be carried on continuously.

THE CONSERVATION OF OUR CEREAL RESERVES.*

THE dangers to which grain stored under ordinary conditions is exposed may be classified under four heads: (1) the attacks of rats and mice, (2) those of insects and mites, (3) those of moulds and bacteria, and (4) the process known as "heating." The amount of damage due to rats and mice is, no doubt, enormous, but might be avoided by any rational system of storage, and is a matter for legislation rather than for scientific investigation. The chief insect pests in this country are the two grain-weevils, *Calandra granaria* and *C. oryzæ*, while in India two other beetles, *Rhizopertha dominica* and *Trogoderma khapra*, are also responsible for much direct injury. Experiments on the rate of multiplication of the weevils show that at suitable temperatures they breed all the year round, but in this country normally only in the warmer months. At about 28°C. a single pair of rice-weevils increased about seven-hundredfold in four months. The accumulated excrement of the weevils attracts moisture and promotes decomposition, accompanied by the evolution of large quantities of ammonia, and in this way the destruction commenced by the ravages of the insects is completed. The process of heating is the result of enzymic action in the wheat itself, sometimes inaccurately spoken of as respiration, though fermentation would be a better term, which increases with rise of temperature (up to about 55°C.) and moisture content (Baily and Gurjar). In the eyes of the trade, heating appears to be a much more serious danger than weevilling. It is at present avoided by abundant ventilation, the grain being turned over as soon as the temperature becomes dangerously high, so as to cool it and carry off moisture.

* Abstract of a lecture delivered at King's College, London, on March 12, under the auspices of the Imperial Studies Committee of the University of London, by Prof. Arthur Dendy, F.R.S., reprinted from *Nature*, dated 20th March, 1919.

As an effectual means of preventing damage from all these sources, air-tight storage should be resorted to. Unfortunately, however, considerable doubt has been thrown on the efficacy of this ancient method by a widespread belief in the ability of weevils to withstand such treatment. This belief rests entirely upon inaccurate observations. Thus we find that tins which are supposed to be hermetically sealed, and look perfectly sound, are often leaky, as can easily be shown by placing them in hot water, when air bubbles are. Numerous experiments made at King's College by the lecturer and his colleague, Mr. H. D. Elkington, who is responsible more especially for the chemical analyses, prove conclusively that all insects present are more or less rapidly destroyed when weevilly wheat is sealed up in air-tight receptacles which it nearly fills. This method of treatment destroys the weevils in all their stages, and is also fatal at any rate to adult mites. The same treatment also prevents the growth of moulds and the process of heating. Two Dewar flasks, filled with grain having a moisture content of 20·7 per cent., were incubated at about 28°C. One was merely plugged with cotton-wool and the other hermetically sealed. In the former the temperature gradually rose to 49·4°C., while in the latter it remained almost stationary. The life of insects and moulds and the process of heating alike depend upon the supply of oxygen, and where this is cut off, no damage from these sources need be feared.

It has been demonstrated experimentally, not only that weevils require an abundant supply of oxygen, but also that carbon dioxide, if present in sufficient quantity, has a directly poisonous action upon them. In pure, moist carbon dioxide they become motionless in three minutes, and can remain in this condition for as much as four days (at room temperature) without losing the power of recovery. A mixture of carbon dioxide with 20 per cent. of oxygen is far more fatal than pure carbon dioxide. This is probably because, in the absence of oxygen, their metabolism is more or less completely suspended, so that the carbon dioxide is unable to exercise its poisonous effect. In a mixture of 56·4 per cent. nitrogen, 20·3 per cent. oxygen, and 23·22 per cent. carbon dioxide weevils became motionless in forty-three hours (at about 30°C.), and after ninety-one hours' exposure, though 19·09 per cent. of oxygen still rem[illegible] revived when supplied with ordinary air.

When wheat is sealed up in a normal temperature, carbon [illegible] accumulates naturally owing to the so-called respiration of the grain, the rate of accumulation depending upon temperature and moisture conditions. At ordinary room temperature (July to October) in three months 300 grammes of English wheat, having a natural moisture content of 15·9 per cent., gave off 58·6 milligrams of carbon dioxide, sufficient to raise the percentage of that gas in the air in the receptacle (which was nearly filled with wheat) to 18·13. If insects be also present, the carbon dioxide accumulates more rapidly owing to the large amount which they themselves give off. It thus appears that in hermetically sealed granaries completely filled with grain there should be no need for any artificial addition of carbon dioxide such as has sometimes been recommended, and indeed, actually made, for the purpose of destroying weevils. Under proper conditions, which ought to be experimentally determined on a large scale, the grain must become self-protective as regards weevilling, mildew, and heating, to say nothing of rats and mice. Any damage which might arise while the carbon dioxide was accumulating would probably be negligible.

The construction of air-tight granaries or silos is a problem for the engineer, but there seems to be no insuperable difficulty in the way. If such granaries existed in the large wheat-growing countries, the grain might be completely sterilized as regards insect-life by storing for a suitable period before shipment, and the very serious weevilling which often takes place on board ship might be avoided. Moreover, it would be possible to equalize shipments all the year round and avoid the rush to get the grain away after harvest. Air-tight storage would also, in all probability, afford by far the best means of maintaining reserves of grain to meet emergencies such as war and [illegible] of crops.

Further details have been, and will be, published [illegible] of the Grain Pests (War) Committee of the Royal [illegible] the auspices of which these investigations have been carried out

THE ENZYMES OF SOME TROPICAL PLANTS.*

BY

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THE scriptural assertion that "man lives not by bread alone" has more than one meaning. Chemists are adding new shades of meaning to it daily through their investigations of the conditions of growth, ripening and vital processes of plants, and their study of the nutrition processes of man and other animals. The simple synthetic food-tablet, which was to carry the necessary food elements—protein, fat and carbohydrates—in the relative proportions demanded by the human body for its growth and development and the performance of its daily duties, now appears to be the dream of a pseudo-scientist. The process of assimilating our daily bread is a much more complex process than was once believed, and the perfect food of the future will hardly be prepared in tablet form. Scientists are beginning to investigate this phase of chemistry and nutrition, and we find such maladies as beriberi, scurvy, and pellagra being attributed to the consumption of a diet deficient in some particular ingredient which has heretofore escaped our notice because of the crude methods used in the examinations of these foods. Doubtless other dread diseases will be found to arise from similar causes or can be controlled by the use of proper food-stuffs.

An interesting part of this field of chemistry, called biological chemistry, pertains to the study of the enzymes and their properties. Much is known regarding enzymes, but much is still to be discovered regarding their functions in the plant's growth and their effect on assimilation processes when taken into the human body along with

* Reprinted from *Tropical Life*, vol. XIV, no. 4.

[illegible]ood. Owing to the uncertainty as to the purity of the separated enzyme, and the impossibility of determining any changes which have taken place in its composition during our attempts to isolate it, the study is very difficult. Thus in many cases we cannot say, when we have finished our study, whether we are dealing with but one compound or several compounds which have defied our attempts at separation; whether we have the compound with which we started, or one formed by a decomposition of the original one due to our attempts at purification. So one learns that the term enzyme is rather general even from this point of view, and when he considers the newness of the subject he can readily realize that many discrepancies have crept in due to faulty procedure on the part of the investigators.

Some of the foods we are accustomed to having served on the table uncooked contain enzymes of various kinds and in different quantities. An interesting speculation is: what influence do these have on the assimilation of the meal at which they are eaten? I shall confine this discussion to a consideration of some of the plants grown in the Tropics. For example, Chittenden[1] has investigated the pineapple and studied the proteolytic enzyme present in it. He called this enzyme bromelin, from the name of the family to which the pineapple belongs. Bromelin is rather resistant to heat, its activity is not destroyed by heating to 70° C., it digests egg albumen and blood fibrin, forming the same products as are formed by the action of trypsin. A rennet-like ferment is associated with bromelin. Instead of purchasing pepsin, which in many cases is worthless because of faulty preparation, it would be more profitable and agreeable to purchase pineapples.

Many persons are acquainted with the proteolytic enzyme which comes from the pawpaw and papaya,[2] and which is sold under the caption, papain. Those who have never eaten the papaya fruit are unfortunate. It has all the virtues of the drug, and besides is a delicious fruit. Probably the proportion of worthless papain on the market is even greater than that of pepsin, since [illegible]

[1] Jou[illegible] of Physiology (1894), XV, p. 249; and Caldwell, Bot. Gaz. [illegible] 407.
[2] Pra[illegible], D. S. *Philippine Journal of Science*, Sec. A (1915), X, [illegible]

is very largely prepared by men who do not understand the necessity of precaution in drying and packing. Then, too, the pharmaceutical supply houses demand a light-coloured product, basing their valuation partly on this property, and this leads to the preparation of an inactive product or the adulteration of the active substance, or both. The drying temperature must not be high if the papain is to retain its digestive activity, but since prolonged drying causes a darkened product much papain is dried at a high temperature in order to avoid a change in colour, and is therefore absolutely worthless. If the product is dried properly and is darkened in the process, the producer often resort to adulterating it with starch to lighten the colour. It is apparent that the buyers should modify their standards and should purchase papain on the basis of its physiological activity. Papain is considered by Euler[1] to be identical with, or at least to resemble, bromelin very closely.

The banana has recently been thoroughly investigated by Bailey[2] for enzymes. This fruit is rich in ferments, giving evidence of the presence of a diastase, an invertase, a protease of the erepsin type, a lipase, while a peroxidase was found at all the stages of ripeness investigated. Thus the banana carries with it enzymes which influence the digestion of starch, sugar, proteins, and fats. In other words, the digestion of your cereal, the sugar which sweetens your cereal and your coffee, the protein of your egg, bacon and milk, and the fat of your egg, bacon and milk is added by the seemingly simple banana you have eaten for your breakfast.

The mango, another popular fruit of the Tropics, contains a proteolytic enzyme which has properties similar to those of bromelin. This investigation is just started by the Bureau of Science, consequently nothing further can be given regarding the identity of the protease with bromelin. But this brief survey of the prominent fruits of the Tropics, the pineapple, papaya, banana, and mango convinces one that these fruits have a value other than that of nutrition, in that they aid in the digestion of other foods.

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[1] Euler. "Pope-General Chemistry of the Enzymes." John Wiley and Sons, New York (1912), p. 39.

[2] *Journ. Amer. Chem. Soc.* (1912), XXXIV, p. 1706.

Considerable differences of opinion prevail among [illegible] in regard to the presence of a lipase in coconuts. [illegible] Lamia[2] report its presence in the germinating meat; W[illegible] the Philippine Bureau of Science, on the other hand, was una[illegible] establish its presence. Deming[4] believes that the lipase [illegible] a zymogen in the coconut which is activated by the addition [illegible] acids, as reported by Green[5] for the lipase existing in ricinus. If such an enzyme exists in coconut meat, it is not destroyed by heating, since meat that has been boiled for some time shows a similar increase in the acidity when the sample is incubated, as is shown by the uncooked meat. This contradicts the general belief regarding the destruction of enzymes by heating in the presence of moisture. However, Sohngen[6] has reported a lipase which he claims is not destroyed by fifteen minutes' boiling. One of the problems involved in the making of coconut oil and the drying of *copra* is the prevention of rancidity. Oils which have become rancid are difficult to make sweet, and Walker[7] states that these oils, after purification, again become rancid more readily than does the virgin oil. He has likewise demonstrated that moisture and oxygen are necessary for the development of rancidity. Lipase alone does not produce rancidity, since rancidity and acidity of oils are not synonymous, and lipase produces only the latter. The Bureau of Science has examined oils with high acid values, the rancidity of which was less than the rancidity of oils with a much smaller acid value.

While the rancidity of coconut oil cannot be attributed to the action of lipase, yet this enzyme splits the esters into glycerol and the constituent acids, and thus renders them in a condition to be more readily acted upon by any other agency. I believe two of

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[1] [illegible] de Dept. de l' Agric. aux Indes-Neer (1906), IV, p. 8.
[2] [illegible] Sperin. Agrar. Ital. (1898), XXXI, p. 397.
[3] [illegible] Journ. Sci., Sec. A (1908), III, p. 111.
[4] [illegible] Agric. and For. (1914), pp. 3–33.
[5] [illegible]en. "The Soluble Ferments and Fermentation," 2nd [illegible] [illegible]ridge University Press.)
[6] [illegible]m. Weekblad (1911), VIII, p. 580.
[7] Loc. cit.

such agencies to be oxidase and peroxidase present in the meat. The action of these enzymes produces acid decomposition products, and these would give the rancid property to oils. It must be remembered that air and moisture are necessary to the production of rancidity in coconut oil, and that, even though the original oxidase and peroxidase have been destroyed by heating, any air allowed access to the oils carries with it mould spores. Impure oils will support mould growth. Dox[1] has demonstrated that these moulds produce all of the enzymes regardless of the character of the substrase, and in this manner rancidity might increase. Then, too, *copra* which has become extremely mouldy yields a more rancid oil than clean, well-dried *copra*. This laboratory[3] has found that oils which have stood in closed bottles for periods of several months give tests for oxidases and peroxidases. That rancidity may be partly due, or in some cases initiated, by the action of oxidases and peroxidases is a plausible speculation.

One of the difficulties encountered in the investigation conducted by the Bureau of Science on the commercial possibility of making sugar from the juice of the nipa palm was due to the presence of a zymogen,[4] which, under atmospheric influence, causes the separation of white, flocculent invertase. The latter rapidly attacks the sucrose present. Invertase action could be inhibited by liming the receptacles for holding the juice, but even then the sugar content gradually decreased. A careful series of experiments proved that some enzyme capable of destroying both sucrose and invert sugar is present in the juice of the nipa palm. It was found that the nipa palm does elaborate a very active enzyme of the peroxidase type. The decreasing alkalinity indicated the formation of acid decomposition products that combined with the lime, and eventually rendered the juice acid and reactivated the invertase. An interesting phase of this investigation was the discovery that only the shorter stalks, or those which have been tapped longest, elaborate the

[1] *Plant World* (1912), XV, p. 40.

[2] The Bureau of Science is now investigating this phase of the rancidity of ...

[3] Notes of an unpublished investigation now in progress.

[4] Gibbs. *Phil. Journ. Sci.*, Sec. A (1911), VI, p. 99. Pratt et al., *ibid.*, Sec. A (1913), VIII, p. 377.

peroxidase. This enzyme is readily destroyed by the ... small amounts of sulphite to the lime cream used for ... receptacles, and makes possible the commercial utili... nipa juice for the preparation of sugar. The use of nipa jui... the manufacture of sugar gives another possible industry to the Tropics.

Enzyme action undoubtedly plays an important part in the curing of tobacco. Oosthuizen and Shedd[1] found invertase, diastase, emulsin and reductase present in appreciable amounts in the seed and leaf at all stages of growth, and also in the cured material. Lipase, inulase and a proteolytic enzyme were found in small amounts, while oxidases were found to decrease from the topping stage to maturity. It is absent in the cured leaf. Protein decreases, while amino-compound simultaneously appear and increase; the starch is converted to sugar, and the sugar later disappears.

Growers of tobacco have learned from experience that certain methods of curing and handling are necessary to obtain good results. For example, in wilting the plant preparatory to placing it in the shed, too high a temperature must be avoided. Such a temperature destroys the efficacy of the enzymes and produces certain other deleterious effects. The phenomenon known as sweating, which takes place when tobacco is packed in bulk in moist air, is a result of enzyme activity and deserves more study from the bio-chemical standpoint, in order that the conditions may be more intelligently controlled.

I have found that cacao contains casease, protease, oxidase, raffinase, invertase and diastase during the various stages through which it passes in fermentation,[2] and believe that the product obtained from this fermentation is largely a result of the activity of these enzymes. Recently I have been able to demonstrate the presence of an emulsin in cacao which hydrolyses amygdalin.[3] ... satisfied that the organoleptic properties of fermented ... superior to those of the unfermented cacao made in this ...

[1] *Journ. Am. Chem. Soc.* (1913), XXXV, p. 1289.
[2] Brill. *Phil. Journ. Sci.*, Sec. A (1915), X, p. 123.
[3] Unpublished investigation.

Since these properties depend largely upon changes in the physical condition of certain constituents of the bean, on chemical changes which can be detected chemically only by very tedious operations, if at all, and upon the production of minute quantities of new compounds, their presence cannot be well demonstrated by chemical analyses. These differences in the quality of cacao are best recognized by an examination of its organoleptic properties.

The Bureau of Science has in progress an investigation of the seeds of the plants belonging to the family to which chaulmoogra belongs. These plants contain a cyanogenetic glucoside[1] in the seeds and other parts which is readily hydrolysed by emulsin, setting free hydrocyanic acid. A hydrolysing enzyme accompanies this glucoside in the plant, consequently when the seeds are bruised the glucoside is hydrolysed, and hydrocyanic acid escapes. The function of these constituents of the above-named plants is not definitely known though various theories are held. Perhaps the most plausible theory is that the free hydrocyanic acid acts as an antiseptic agent when the plant is bruised, thus preventing further injury to the plant from bacterial action or fungus growth, but it is possible that this same factor has an influence on the efficacy of the chaulmoogra oil used in the treatment of leprosy. It is well known to those administering chaulmoogra oil to lepers that only the crude oil has any effect. This effect may possibly be due to the presence of the cyanogenetic glucoside in the oil, either alone or associated with the ferment and free hydrocyanic acid. This is one phase of the problem of the treatment by means of chaulmoogra oil that the Bureau of Science is at present investigating.

The rolling of tea breaks the cell walls of the leaves and releases the ferments. This process, "oxidation process," or "fermenting," Bamber[2] says, "is perhaps the most important in the whole manufacture, as both the quality and appearance of tea depend largely on the process being properly carried out."

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[1] Power, et al. *Journ. Chem. Soc.* (1904), LXXXV, p. 838; *ibid.* (190[illegible]) LXXXV[illegible], p. 884. De Jong. *Recueil des Travaux chimiques des Pays-Bas et de la B[illegible]* (19[illegible]), XXVIII, p 25; *ibid.* (1911), XXX, p. 220.

[2] "Tea Cultivation in Ceylon." Colombo: A. M. and J. Ferguson (1894), p. [illegible]

Coffee undoubtedly undergoes fermentation in the [illegible] and wet processes. An investigation of the nature of these [illegible] should be made in order that the changes taking place [illegible] be understood. Control of these changes would undoubtedly [illegible] a better quality of coffee.[1]

It is generally conceded[2] that the darkening of rubber is due to the action of an oxidase. Its action can be prevented by heating the rubber and thus destroying the enzyme, or by keeping the rubber from coming in contact with the air when being coagulated. When interviewed by the *Times* of Ceylon, Bamber[3] said: "It is advisable to ensure the destruction of the enzyme which occurs in the latex, together with certain organic products, which darken on exposure to the air. The enzyme has an effect very similar to the enzyme in tea." The matter of enzymes and their effect on rubber, the use of inhibiting agents, etc., deserve further investigation.

In the article cited above, Armstrong is quoted as saying that no adequate sum of money has ever been appropriated for the investigation of rubber in the field. Such a state of affairs should be remedied without delay.

In conclusion, I wish to note that moulds elaborate all the known enzymes, and in many cases have considerable influence because of this property. Dox[4] has demonstrated the presence in moulds of protease, nuclease, amidase, lipase, emulsin, amylase, inulase, raffinase, sucrase, maltase, lactase, histozyme, catalase, and phytase, and has shown that these are formed regardless of the nature of the substrase. That the character of the substance has no influence on the type of enzyme formed is another evidence of the prodigal character of Nature and her preparedness for any emergency. This discovery throws light on the manner in which moulds do their works. The study of enzymes and their influence is just begun. We can look forward to many new and [illegible] discoveries in this field and more extensive generalizations.

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[1] See also what is said in our book, "The Fermentation of [illegible] Publishing Department, price 10s. net.

[2] Eaton, B. J. "The Preparation of Plantation Para Rubber [illegible] Federated Malay States (1912), Bulletin 17.

[3] Tropical Life (1908), IV, p. 123.

[4] *Loc. cit.*

Notes.

MOTOR TRACTOR TRIAL AND DEMONSTRATION.

AT the Pusa Farm, on Friday, 30th May, 1919, a trial and demonstration of the capabilities of the Fordson Motor Tractor was given by the Offg. Imperial Agriculturist, Mr. Wynne Sayer. The tractor was worked with a heavy two-furrow Ransom disc plough, a Ransome's spring tine cultivator, a Cambridge roller and a rake of three [illegible] harrows. The trial was watched with great interest by a large crowd of planters, zemindars and officials. At the conclusion of the work on the land, the tractor was run up to the farm buildings and used to drive a Climax silage cutter. The greatest interest was evinced in the work done, as this is the first tractor of its type to be used in India. Experiments will now be started on the farm to determine working costs, etc. An account of the trial, with photographs, will appear in the next number of this *Journal*.

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AN ATTACK OF *NEPHANTIS SERINOPA* ON COCONUT PALM IN TRAVANCORE.

THE attack of *Nephantis serinopa* on coconut palms in the Quilon town and the adjacent areas in Travancore was reported towards the end of May, 1918. On inquiry, it was found that the outbreak of this pest commenced nearly one year ago on a few palms in a churchyard, and that in the course of a year it attacked more than 9,000 palms.

Some *raiyats* thought that the drying of the leaves was due to the influence of small-pox, which was prevalent in a virulent form at that time; while others believed that it was due to the effect of smoke emanating from the tile factories of Quilon. The affected trees looked faded as if they suffered from the effect of severe drought, and the leaves, especially the matured ones, dried up. In extreme

... *Nephantis serinopa* in its larval, ... and imago stages (Natural size).

Fig. 2. A palm tree the affected leaves of which have been removed.

Fig. 3. The affected leaves showing the different stages of the attack.

Fig. 1. Palms damaged by *Nephantis serinopa.*

Fig. 2. A group of treated palm trees.

few the palms died of the attack. In ordinary cases, the health as well as the yielding capacity of the palms was considerably reduced, and such palms took more than a year to regain their normal condition.

The insect completes its life-history on the foodplant itself. The eggs are found on the damaged leaves. The larva is not an open feeder. It makes a gallery of silken and excrementitious matter on the lower surface of the pinnæ in such a way that one would be tempted to think that the larva is a leaf roller. That the damage done by *Nephantis serinopa* differs very much from that of the Limacodid larva, the attack of which on coconut palm was recorded towards the commencement of the year 1914, is clear from the fact that the latter eats away openly the leaf blade, leaving only the midrib of the pinnæ; whereas the *Nephantis serinopa* makes a gallery on the under-surface of the leaf and eats away only the green tissue of the leaf blade from within the gallery.

The full-grown larva measures a little more than 20 mm. in length. Pupation takes place on the damaged leaves of the food-plant. The larva can be seen throughout the year. The moth is attracted to light, but not so readily as *Schœnobius bipunctifer*.

The pest is new to Travancore. Spraying with contact and stomach poisons was done on young trees with some success. The process of cutting and burning the affected leaves has a decided effect in keeping the pest under check. This was recommended to the *raiyats* and they adopted it with success. More than 3,888 trees were treated, and nearly 24,248 leaves were cut and burned. When the *raiyats* were fully convinced of the efficacy of this treatment, they themselves carried out the work without much external pressure and the pest was completely brought under control.—[K. Madhavan Pillai.]

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PERENNIAL FORAGE SHRUBS.

In a previous number of this Journal[1] appeared a short account of the trials of exotic drought-resisting plants in India from the pen

[1] *The Agricultural Journal of India*, vol. II, part II, 1907.

of Mr. (now Sir) Frank G. Sly in which he deprecat[es] any ... extensive trials of exotic plants except perhaps in a[rid] tracts, as Sind, Rajputana and the Western Punjab. The foll[owing] ... however, reproduced from the *Agricultural News*, Ba[rbados], ... July 13, 1918, with the hope that some of the Provin[cial] Departments of Agriculture in India interested in the questi[on] of drought-resisting plants will give a trial to the three ... which appear to be of good promise. It should be ... however, that the first of these has already been tried in the ... Provinces and failed to stand the heat.

" Experiments which are being made in the Botanic Gard[ens], Sydney, as to the fodder value of three useful leguminous ... from Teneriffe, are noticed in the *Agricultural Gazette of New S[outh] Wales*, April, 1918. The first of these, *Cytisus proliferus*, is k[nown] in its native island as Tagasaste. This is stated to be a leafy ... with a graceful drooping habit, which does well under dry conditi[ons] and stands considerable variations in temperature from hot to ... Its quick growth makes it useful as a wind-break, and if kept trimm[ed] it grows into a pleasing shrub from 8 to 15 feet high. For fodde[r] purposes, it should never be allowed to grow into a small tree, ... should be cut regularly at least twice a year; the foliage is the[n] always young and soft, and in this state it is readily eaten by ... kinds of stock. It is recommended as a safe and profitable stand-by in districts where droughts interfere with the cultivation ... better fodder.

" The second shrub of the same genus is *C. stenopetalus*, ... Gacia in Teneriffe. This makes a beautiful, sweet-scented, yello[w] flowering shrub, not so large in growth as the Tagasaste, but ... as robust, producing thick green foliage.

" The third of these shrubs, *C. pallidus*, is known as Gacia ... and is even more beautiful as a shrub than the Gacia, because of ... charming silvery foliage, although both species bear the sa[me] yellow flowers.

" Both the Gacias make excellent fresh fodder and ... if cut in the same way as the Tagasaste. The flowers ...

of them yield large quantities of nectar, and are exceedin... to bee-keepers.

"Dr. G. V. Perez of Teneriffe is interested in having the plants experimented with in various parts of the world, and ... probably be glad to supply seeds for trial in any of the drier W... Indies."

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THE following extracts from official reports dealing with the use of cactus in the Ahmednagar District as a fodder substitute have been published by the Bombay Government :—

...ract from a Report by Mr. E. Weston, I.C.S., Assistant Collector, Ahmednagar, dated 15th March, 1919.

CENTRAL camps were opened in January at Sheogaon and ...ewasa. Cattle were taken from agriculturists willing to have their cattle fed upon cactus. Such cattle are kept in the camp for about ... month at Government expense, and being accustomed to the ... are returned to their owners, who are given every facility and encouragement to continue using the fodder.

In the early stages we were dependent upon blow-lamps for burning off the cactus thorns. These proved unsatisfactory for village use, as they continually went wrong. At the end of January, blacksmith's forges were tried, and their satisfactory working has made it possible for villagers to prepare cactus cheaply and easily in their own villages.

The large blacksmith's forge is expensive, and it is difficult to obtain a large supply of them quickly. Equally good results are obtained by the use of small hand bellows. Arrangements have been made to obtain about 100 pairs of these.

Now that the technical difficulties in the way of preparing the fodder without elaborate apparatus are removed, it has become possible to expect villagers with a little encouragement and assistance to take up the idea themselves. The following is an ... of work done with that purpose.

The central camps have been increased to four ... camps at Tásgaon and Páthardi. In these the cattle ... are admitted and fed for a month. The own... ...

encouraged to visit the camps and learn the method of preparing. Mamlatdars use the camps as offices when hearing petitions from *tagai** applicants. On the road outside the camp a man is posted with a box of prepared cactus which he offers to cartmen or other passers-by willing to take it for their cattle. At Sheogaon we are now in a position to ask a price for such prepared cactus.

The progress made among the villagers is greatest in Sheogaon *taluká* and least in Páthardi *mahál*. Sheogaon is the area in which famine is most severe; Páthardi that in which it is least so.

In Páthardi, no villages have gone in for cactus-feeding seriously. In Newása *taluká*, 27 villages are feeding about 450 cattle. Here the average number per village is small, and we are still in the experimental stage when villagers send their useless cattle to try the fodder before giving it to their working animals.

In Sheogaon, about 800 animals are being fed in 30 villages. Among these 30 villages there are several in which a further stage than the experimental has been reached. The following gives the number of animals fed in five of the most advanced villages:—

	Animals
Thakur Nimbgaon	150
Ghotan	75
Balam Takli	60
Dor Jalgaon	52
Avhane	35

In all these villages the work is managed by the villagers. They have been assisted by grants of hand bellows and pincers, and cotton seed and grass given on *tagai*.

The best example of village organization is the village Ghotan. The work is managed by a "Panch" of the leading inhabitants. The villagers have subscribed towards working expenses. Cactus is prepared morning and evening, and distributed to the owners of the cattle. Those in poor circumstances receive it free, and others pay from 2 to 4 annas per 100 pounds. The *talathi*† is keeping a register showing the animals fed and the amount of fodder distributed. The cactus is prepared by the village *lohar*‡ and his son, who are bei

* Takavi. † Village accountant. ‡ Blacksmith.

remarkably skilful. Each receives six annas a day from the ... "Panch." The services of the members of the famine ... the village are used for cleaning the burnt cactus. The chopping is done by the village *mahars*.* The animals are in excellent condition, and the large proportion of them are working animals. I have every hope that similar organizations will be instituted in many more villages of Sheogaon and Newása *talukás*. If this is successful, prickly pear feeding in famine times will have become established.

I may mention as a proof of the growing belief in the fodder that the people of Ghotan, besides undertaking their own camp, have subscribed Rs. 150 towards the work of popularizing the use of prickly pear in Sheogaon *taluká*.

Extracts from a Report by Mr. C. A. Beyts, O.B.E., I.C.S., Collector of Ahmednagar, dated 28th March, 1919.

Mr. Weston's figures are now about three weeks old. There are now over 4,000 village cattle subsisting mainly on cactus.

* * * * *

The consumption of cactus in Newása and Sheogaon is already equivalent to about 12 lakhs of pounds of grass per mensem, and the value of the work done in these *talukás* can be judged from the fact that the supply of Government grass is practically exhausted already and that no more is required, though two months of the fodder famine remain in the best of circumstances.

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HOW TO AVOID INTERMITTENT BEARING OF FRUIT TREES.

In a recent article in *Country Life*, it is maintained that the intermittent bearing of fruit trees can be avoided by a proper system of manuring. The writer, H. Vendelmans, says that, in spite of a very common belief, it is certain that the bearing capacity of fruit trees is not limited to every other year. Ninety-one orchardists out of every hundred in England assert that a good crop is followed by a thin crop, and *vice versâ* ; but the regularity with which excellent returns are obtained annually from espalier trees, and ...

* Butchers.

glass, which received different treatment from that ...ted out to orchard trees, ought to suggest some scepticism about the old tradition. In the case mentioned, it is possible to rely on good crops every year. Among the reasons which explain this more regular bearing, manure takes a first place. Without it, the abundant crop of one year makes so great a demand upon plant food that the reserves of the trees are exhausted, and are not strong enough to feed a new crop for the next year. Hence a poor return follows a good return. In the year following the bumper crop, the trees often carry no fruit at all, but they accumulate new reserves, and are then ready to feed a large crop the next year. When the exhaustion of the trees is prevented by appropriate manuring, bearing takes place much more regularly.

In manuring fruit trees, it is necessary to bear in mind that the blossom buds are formed the year before they come out, that is to say, during the period of bearing or shortly afterwards. Consequently, they are forming at a time when the trees are being exhausted, or have been exhausted. Therefore, a liberal supply of easily assimilable manure must be placed at their disposal during this period. Liquid manure, wood-ashes, basic slag, and lime should be used, taking into account that a superabundant supply of nitrogen might lead to a production of wood instead of flower buds, and that phosphates assist in developing the flavour of the fruit.

This serves to emphasize the essential use of manures in orchard cultivation, if the best results are to be attained. [*The Agricultural News*, dated 5th October, 1918.]

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COTTON-SEED FLOUR FOR HUMAN CONSUMPTION.

MR. ED. C. DE SEGUNDO, in the course of his paper on "The Removal of the Residual Fibres from Cotton-seed and their Value for Non-textile Purposes" read before the Royal Society of Arts said :—

A highly nutritious flour suitable for human consumption has been produced in large quantities in America during the war from the residue of the meats after the oil has been extracted. This flour.

ch it is stated, has been recommended by the United States ernment as a diluent for wheat, is being manufactured in large ntities in the United States. It is called "Allison" flour in our of its originator, the late Colonel J. W. Allison, of Ennis, Texas. ontains about 50 per cent. of protein and 8 per cent. of fat, and is tically starch-free. Wheat flour, as is well known, shows on lysis about 11 per cent. of protein, about 2 per cent. of fat, and tains a high percentage of starch. The coefficient of digestibility the protein in Allison flour is stated to be about 88 per cent., while t of the protein in wheat flour is about 94 per cent. Thus, the tein and fat content of cotton-seed flour is about five times that wheat flour, and while, on this account, bread should not be made ely from cotton-seed flour (except under medical advice in cases ere a starch-free diet is a necessity), cotton-seed flour is eminently itable for mixing with wheat flour and potato flour. By the dicious use of cotton-seed flour a wholesome and palatable bread n be made, possessing the same nutritive properties as the all-heat loaf, while effecting a considerable reduction in the actual antity of wheat flour used. For example: A mixture of 5 per nt. cotton-seed flour, 10 per cent. potato flour, and 85 per cent. wheat flour (percentages calculated on the weight of solids only), ould produce a loaf containing a rather higher percentage of otein than that found in the all-wheat loaf of pre-war days. As e wheat consumption in this country was over 6,000,000 tons per num, on the average, over a period of years immediately preceding he war (of which about 5,000,000 tons had to be imported) the ossibility of effecting a saving of 15 per cent. of our normal require-ments of wheat flour is a matter to which serious consideration ight usefully be given. I have dealt at some length with the properties of cotton-seed flour in a paper read before the London Section of the Society of Chemical Industry on March 25th, 1918. [*Journal of the Royal Society of Arts*, dated 14th February, 1919.]

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Vegetable-drying, which has reached such extraordinary evelopment in Central Europe, is an emergency industry, and

Dr. Eisener has predicted its decline after the war. Before the war, however, in 1913-14, Germany dried 11,500,000 hundredweight of potatoes. The potato-drying capacity has been since increased to 37,000,000 hundredweight; and a recent census showed the drying plants of Germany to include 700 especially designed for potatoes, 150 for corn, 400 for cabbage, 400 for partly dessicating different products, 250 for various vegetables, and 22 for milk. Even kitchen refuse has been dried in some of the larger cities. Studies are said to be still in progress of the best methods of drying to retain original flavours, and experiments on the best ways of cooking have been made. The German demand has built up large drying establishments in Holland, where dried vegetables have been little used. One drier estimates that the processes now employed in Holland reduce the weight of root vegetables, including potatoes, about 80 or 85 per cent.; and of such vegetables as celery, cabbage, lettuce, etc., as much as 90 or 93 per cent.—[*Capital*, dated 28th March, 1919.]

PERSONAL NOTES, APPOINTMENTS AND TRANSFERS, MEETINGS AND CONFERENCES, ETC.

WOODHOUSE-SOUTHERN MEMORIAL FUND.

		Rs.
DONATIONS received up to the 28th February, 1919, and acknowledged in the *Agricultural Journal of India*, Vol. XIV, Pt. II, April, 1919.		1,030
Donations received during the period from 1st March, 1919, to 31st May, 1919 :—		
	The Hon'ble Mr. C. A. H. Townsend, I.C.S. (S) ..	10
	G. Milne, Esq., I.C.S. (W)	100
	A. McKerral, Esq.	50
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	L. C. B. Glascock, Esq. (S)	10
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	Pandit Chandan Ram (S)	5
	Malik Barkat Ali (S)	[illegible]
	G. C. Sherrard, Esq.	[illegible]
	B. M. Chibber, Esq.	[illegible]
	TOTAL ..	Rs. [illegible]

HIS MAJESTY THE KING-EMPEROR'S BIRTHDAY HONOURS List contains the following names which will be of interest to the Agricultural Department :—

K.C.I.E. THE HON'BLE MR. C. E. LOW, C.I.E., I.C.S., Secretary to the Government of India, Department of Commerce and Industry (sometime Director of Agriculture and Industries, Central Provinces and Berar).

C.S.I. THE HON'BLE MR. R. A. MANT, B.A., I.C.S., Offg. Member of the Council of the Governor-General of India, in charge of the Revenue and Agriculture Department.

C.I.E. MR. H. C. BARNES, M.A., I.C.S., Offg. Commissioner, Surma Valley and Hill Districts (sometime Director of Land Records and Agriculture, Eastern Bengal and Assam).

MR. H. CLAYTON, M.A., I.C.S., Offg. Commissioner of Settlements and Land Records, Burma (sometime Director of Agriculture, Burma).

MR. D. CLOUSTON, M.A., B.Sc., Offg. Director of Agriculture, Central Provinces and Berar.

C.I.E. (*War Services*). MR. C. A. INNES, I.C.S., Food Controller and Joint Secretary to the Government of India, Revenue and Agriculture Department.

C.B.E. MR. C. G. LEFTWICH, I.C.S., Controller of Civil Supplies, Central Provinces and Berar (sometime Director of Agriculture, Central Provinces and Berar).

* * *

THE HON'BLE SIR CLAUDE HILL, K.C.S.I., C.I.E., I.C.S., Member of the Council of the Governor-General of India, in charge of the Revenue and Agriculture Department, has been granted leave on medical certificate for a period of four months from 9th April, 1919.

THE HON'BLE MR. R. A. MANT, B.A., I.C.S., officiates for Sir Claude Hill, and Mr. J. Hullah, I.C.S., acts in place of Mr. Mant.

Secretary to the Government of India in the Revenue and Agriculture Department.

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MR. J. MACKENNA, C.I.E., M.A., I.C.S., Agricultural Adviser to the Government of India and Director, Agricultural Research Institute, Pusa, has been granted privilege leave for six months from the 13th April, 1919.

MR. G. A. D. STUART, B.A., I.C.S., has been appointed to officiate in place of Mr. Mackenna.

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MR. G. S. HENDERSON, N.D.A., N.D.D., Imperial Agriculturist on deputation under the Indian Munitions Board as Controller, Agricultural Requirements (Mesopotamia). Poona, is granted privilege leave for three months from the date of his relief from the Munitions Board.

MR. WYNNE SAYER, B.A., will continue to act as Imperial Agriculturist, during the absence of Mr. G. S. Henderson on privilege leave.

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MR. R. CECIL WOOD, M.A., Principal of the College of Agriculture, Professor of Agriculture and Superintendent of the Central Farm, Coimbatore, has been appointed to act as Director of Agriculture, Madras, during the absence of Mr. Stuart.

MR. W. McRAE, M.A., B.Sc., F.L.S., Government Mycologist, officiates as Principal of the College of Agriculture, Coimbatore, and Mr. Roger Thomas, B.Sc., Deputy Director of Agriculture, acts as Professor of Agriculture and Superintendent of the Central Farm, Coimbatore, *vice* Mr. Wood.

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DR. C. A. BARBER, C.I.E., Government Sugarcane Expert, Madras, has been granted combined leave for six months from the 12th April, 1919, and has been permitted to retire from service on the expiry of the leave.

MR. T. S. VENKATARAMAN, B.A., Assistant Government Sugarcane Expert, Madras, has been appointed to act as Government Sugarcane Expert until further orders.

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MR. F. R. PARNELL, B.Sc., Government Economic Botanist, Madras, has been granted combined leave for 12 months from 30th April, 1919.

MR. G. N. RANGASWAMI AYYANGAR, B.A., has been appointed to officiate for Mr. Parnell until further orders.

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MR. G. R. HILSON, B.Sc., Deputy Director of Agriculture, II & III Circles, Madras, has been granted combined leave for 13 months from 1st May, 1919.

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MR. K. T. ACHAYA, Assistant Director of Sericulture, Jammu, has been appointed temporarily as Sericultural Expert in the Agricultural Department, Madras.

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RAO BAHADUR K. RANGA ACHARIYAR, M.A., Government Lecturing and Systematic Botanist, Coimbatore, was granted privilege leave for three weeks from 15th May, 1919.

MR. C. TADULINGAM MUDALIYAR acted as Government Lecturing and Systematic Botanist, during Mr. Ranga Achariyar's absence.

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* *

MR. T. V. RAMAKRISHNA AYYAR, B.A., F.E.S., F.Z.S., Acting Government Entomologist, has been granted privilege leave for two months from or after 5th May, 1919.

MR. Y. RAMACHANDRA RAO, M.A., has been appointed to officiate as Government Entomologist, *vice* Mr. Ramakrishna Ayyar on leave or until further orders.

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MR. S. MILLIGAN, M.A., B.Sc., Director of Agriculture, Bengal has been allowed combined leave for seven months.

MR. R. S. FINLOW, B.Sc., F.I.C., Fibre Exp[illegible] Government of Bengal, officiates as Director of Agricul[illegible] addition to his own duties, during the absence of Mr. Ma[illegible]

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MR. H. E. ANNETT, B.Sc., F.C.S., Agricultural Chemist [illegible] Government of Bengal, has been allowed combined leave [illegible] months.

MR. G. P. HECTOR, M.A., Economic Botanist to the Government of Bengal, has been appointed to act as Agricultural Chemist, Bengal, in addition to his own duties, *vice* Mr. H. E. Annett on leave.

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MR. A. D. MACGREGOR, of the Civil Veterinary Department, Bengal, has been allowed privilege leave for three months.

***

MR. H. M. CHIBBER, M.A., has been appointed Plant-Breeding Expert to the Government of Bombay, with effect from 1st January, 1919.

***

MR. T. F. MAIN, B.Sc., Deputy Director of Agriculture in Sind, has been granted combined leave for six months from 6th May, 1919.

MR. GUL MAHAMMAD ABDUR RAHMAN, Divisional Superintendent of Agriculture in Sind, acts for Mr. Main pending further orders.

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MR. W. M. SCHUTTE, A.M.I.MECH.E., Agricultural Engineer to Government, Bombay, has been granted, with effect from 27th April, 1919, combined leave for six months.

MR. G. H. THISELTON DYER acts as Agricultural Engineer during Mr. Schutte's absence.

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MR. G. C. SHERRARD, B.A., Deputy Director [illegible] Patna Circle, on his reversion from military duty [illegible] with effect from the 17th February, 1919, on special duty in connection with the closing of the Bankipore Agricultural Farm and the establishment of the Ranchi Asylum Dairy, and the Experiment and Seed Farms at Purulia and Ramgarh.

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SUBJECT to confirmation by His Majesty's Secretary of State the Government of India have sanctioned the re-employment of Mr. M. M. MacKenzie as Superintendent of the Sipaya Cattle Breeding Station for a further period of five years.

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MR. B. C. BURT, B.Sc., M.B.E., Deputy Director of Agriculture, Central Circle, United Provinces, has been granted privilege leave for six months, with effect from the 4th April, 1919.

RAI SAHIB NAND KISHORE SHARMA, Divisional Superintendent of Agriculture, Central Circle, Cawnpore, officiates in place of Mr. Burt.

***

MR. H. M. LEAKE, M. A., Economic Botanist to the Government of the United Provinces and Principal, Agricultural College, Cawnpore, has been granted combined leave for ten months, with effect from the 16th April, 1919.

MR. G. CLARKE, F.I.C., Agricultural Chemist to Government, United Provinces, officiates as Principal, Agricultural College, Cawnpore, *vice* Mr. Leake granted leave.

MR. W. YOUNGMAN, B.Sc., Assistant Economic Botanist to Government, United Provinces, officiates as Economic Botanist *vice* Mr. Leake on leave.

***

MR. F. J. WARTH, M.Sc., B.Sc., Agricultural Chemist, Burma, has been granted combined leave for six months.

***

MR. T. RENNIE, M.R.C.V.S., Second Superintendent, Civil Veterinary Department, Burma, has been granted combined leave for six months.

SECOND-LIEUT. (T. LT.-COL.) R. J. D. GRAHAM [illegible] been mentioned by Lt.-General W. R. Marshall, K. [illegible] Commanding-in-Chief, Mesopotamia Expeditionary [illegible] despatch, dated 11th November, 1918, for distinguished [illegible] services and devotion to duty.

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THE services of Mr. G. Evans, M.A., Deputy Director of Agriculture, Central Provinces, have been placed temporarily at the disposal of the Government of Burma.

MR. J. H. RITCHIE, M.A., is appointed to act as Deputy Director of Agriculture, Northern Circle, Central Provinces, *vice* Mr. G. Evans.

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MR. J. N. CHAKRABARTI, Superintendent of Agriculture, on deputation, has been appointed to officiate as Second Deputy Director of Agriculture, Assam, from the 16th May, 1919.

***

MR. J. G. CATTELL, M.R.C.V.S., Superintendent, Civil Veterinary Department, Sind, Baluchistan and Rajputana, has been granted combined leave for two years.

Reviews.

Soil Biology. Laboratory Manual.—By A. L. WHITING, Ph.D., Assistant in Soil Biology in University of Illinois, College of Agriculture and Agricultural Experiment Station. Pp. ix+14? (New York: John Wiley & Sons; London: Chapman & Hall Ltd.)

Extract from preface:—"The purpose of this Manual is to present the important principles of soil biology, particularly as they point to the intelligent control of the essential elements of plant food. The principles are incorporated in practices which acquaint the student with the various forms of life in the soil and their activity. . . . . . Emphasis is laid upon quantitative results, and the measure applied consists of bio-chemical and chemical methods."

The small volume is divided into two parts.

Part I contains the practices referred to in the preface, a total of thirty-three, with numerous questions and references to recent literature. The subjects dealt with include soil plating, the nitrogen cycle, the sulphur cycle, fungi and algæ in soils and their relation to soil nitrogen, ærobic and anærobic decomposition of cellulose, protozoa in soils, enzymes, iron bacteria, decomposition of cyanamid, cross inoculation of legumes, and the solvent action of soil bacteria on minerals.

Part II contains clear and concise descriptions of the bacteriological, chemical, mechanical and pot culture methods applied in the Illinois laboratory, and a list of reagents, chemicals and apparatus for the teaching of soil biology.

The volume is a most useful addition to previous manuals. [J. H. W.]

* * *

We welcome in pamphlet form the very interesting lecture on the subject of **Agricultural Organization in Bengal,** delivered on the 28th March, 1919, under the auspices of the Bengal Co-operative Organization Society, by Mr. G. S. Dutt, I.C.S., Collector of Birbhum. The three main propositions which he lays down are that agriculture is still the greatest industry in the country, that in the application of science to the practice of husbandry lies the path of advance, and that an agency for the dissemination of such knowledge can be created by the combined application of the principles of decentralization and co-operation. The first two are universally accepted. The main interest of Mr. Dutt's lecture lies in the account he gives of the system of Branch Agricultural Associations which have been constituted in the district of Birbhum for the purpose adumbrated in the third proposition. Provincial, Divisional, and District Agricultural Associations are, in this country, perhaps as old as the Agricultural Departments themselves and many have done useful work, but generally it may be said that the work is of a spasmodic character and carried on by individuals rather than by the association in its corporate capacity. This has been mainly due to the areas of their activities being too large and the associations containing too few practical agriculturists. To meet this difficulty, the Birbhum District Agricultural Association evolved a system of Branch Agricultural Associations of members residing within the area of a Police Thana. This proved so popular that even the area of a Thana is now considered too large for effective corporate work, and associations are being formed on a much smaller territorial basis. The number of such branch associations has, during four months, increased from 16 to 30. These branch associations in their present form, Mr. Dutt describes as "associations of farmers large and small, literate and illiterate, *bhadralog* and peasant for the purpose of mutual discussion and dissemination of information ... purchase of seeds, manures and implements ... ing new varieties and improved methods recommended by the officers of the Agricultural Department." During the first year of their existence these bodies indented for new manures, seeds of superior varieties of paddy, wheat, groundnut and other crops, as well as improved varieties of sugarcane cuttings, etc., worth about Rs. 8,000. In the present year, the indents are expected to be about Rs. 14,000 in value. These are no mean figures for the first year's work in a backward small district. But these associations are not mere agencies for distribution of seeds and manures. "They provide a basis for practical combination of farmers with a view to the securing of important agricultural information and they constitute practical rural schools in which the members learn from each other's example the lessons of agricultural improvement." Moreover, when the full scope of their usefulness is developed, there will hardly be an agricultural problem in the solution of which these associations cannot play an important part. Mr. Dutt is of opinion, and we agree with him, that the organization of such bodies will most usefully supplement the activities of the Co-operative Department, and that without some such organization no scheme of rural reconstruction will have any chance of success. Agricultural development as well as expansion of the co-operative movement has, in every one of the most progressive countries in agriculture, been preceded and fostered by a system of farmers' associations in the villages on lines similar to the Birbhum system. Mr. Dutt therefore appeals to all public-spirited people in the other districts of Bengal to equip themselves with this healthy and natural system of rural and national reconstruction which is such a crying need in Bengal to-day. Government, he says, have ensured fair rent, fixity of tenure and free sale; Government are providing the required expert officers and farms for research work; and now the people themselves should take up the work of organization and combination and of untiring effort towards improvement through combined action. We hope Mr. Dutt's appeal, backed by the example of Birbhum, will not fall on deaf ears. [EDITOR.]

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Agricultural Statistics of India, 1916-17, Vol. I.—This annual volume is the thirty-third of the series started in 1886, with atistics for 1884-85, and has just been issued by the Department f Statistics, India. A map showing the departure from ormal of the cropped area and of the rainfall in 1916-17, five harts showing total area cropped, food-crops area, cultivable rea, irrigated area, fallows, etc., and three diagrams showing areas nder different crops, live-stock, and shares of provinces in the total rea under principal crops, introduced for the first time this year, ave added considerably to the usefulness of the publication. The liagrams bring out a close correlation between the total rainfall and he area cropped.

The total area of India, including Burma, is 1,151,336,000 acres, and this volume deals with the 616,160,000 acres out of this which are in British India, excluding Indian States. After allowing for forests, buildings, water, roads, etc., we find that 63 per cent. of this total remains available for cultivation. The net area actually cropped in the year was, however, 229,709,000 acres, or 37 per cent. of the total area, as against 221,778,000 acres in the preceding year, or an increase of 3·6 per cent. The area under food-grains showed an increase of 5,340,000 acres or 2·6 per cent. as compared with the preceding year. Of oilseeds, sesamum, rape and mustard somewhat declined, but linseed and other oilseeds increased by 406,000 acres. Sugar showed an increase of 40,000 acres, while the increases under cotton and jute were 2,401,000 and 323,000 acres, respectively.

From the second map and the charts it can be deduced that the general increase in cropped area was mainly due to a rainfall well above the average, but no table of rainfall is given in the volume. We suggest that this might be included in future.

It is admitted that the figures in Table VI, which deals with transfers of land, are incomplete. Madras has discontinued the return since 1913-14, and we suggest that it would be best to omit the whole table in future. The publication of incomplete figures serves no useful purpose. The volume closes with two useful appendices giving lists of vernacular terms and names of crops. We notice some errors in these, e.g., *Dividivi* is more of a tanning stuff than a dye and *Kolinji* (*Tephrosia purpurea*) is a green manure crop and not a drug; while the definitions of the vernacular terms *Inam, Zamindar, Zamindari* might well be made more illuminating.—[EDITOR.]

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* *

THE October-December (1918) Number of the **Bulletin of the Imperial Institute** (London : John Murray, 2*s*. 6*d*.) contains a comprehensive article on the Empire's trade in wool in its relation to the wool trade of the world. The total amount of wool produced is estimated at about 3,000 million pounds, of which almost two-fifths is contributed by British countries, Australia alone producing nearly one-fifth. Of the 460,000,000 lb. of imported wool used in the United Kingdom before the war, more than three-quarters came from British sources. Nevertheless, as is pointed out, Germany was actually using more Australian and South African wool than the United Kingdom. It is interesting to note also that the total consumption of wool in Germany was greater than in the United Kingdom, but it was chiefly of the inferior kinds. During the three years before the war the United Kingdom was exporting woollen manufactures of the average annual value of 27 million pounds sterling. Since then the growth of the industry has been remarkable. The average annual value of the exports of woollen manufactures has increased to over 36½ million pounds, and at present nearly twice as much wool is being used by the weaving industry as in pre-war times, and nearly the whole of it comes from within the Empire.

The article includes an account of the production of wool within the Empire and in foreign countries, and full particulars are given of the trade in woollen goods of the United Kingdom, the chief European countries, the United States and Japan.

The same number of the Bulletin contains an informative article on the manufacture and industrial utilization of paper yarns, which, during the war, were so largely used in Germany for fabrics of various kinds owing to the scarcity of jute and cotton. The manufacture of cordage and fabrics from paper yarn has been carried on in this country; but it appears unlikely that any extensive development of the industry will take place here so long as ample supplies of jute are obtainable at a reasonable price.

REVIEW

The section of the Bulletin devoted to an account of [illegible] igations conducted at the Imperial Institute includes a second [illegible] on samples of rubber prepared in Ceylon, in order to ascertain [illegible] best methods of preparing plantation rubber of the quality required by manufacturers; a report on the value of Indian tea seed as a source of oil; and a report on minerals from Rhodesia, including a general summary of the mineral resources of that country.

Correspondence.

A NEW USE FOR SUGAR IN THE CURING OF RUBBER.

To the Editor,

The Agricultural Journal of India.

Sir,

In the *Agricultural Journal of India*, Vol. XIII, Pt. IV, October, 1918, page 731, is a note headed " A new use for sugar in the curing of rubber," abstracted from the *Philippine Agricultural Review*, which attributes the discovery to Drs. Swart and Ultee of Java.

I should like to point out that this discovery was originally made by me in the laboratories of the Agricultural Department, F. M. S. (vide *Agricultural Bulletin*, Vol. IV, No. 2, November, 1915, page 26; and Vol. V, No. 2, November, 1916, page 48). Had reference been made to the original publication from Java by Drs. Gorter and Swart (*West Java Rubber Testing Station Bulletin* No. 6), the error in attributing the discovery to the above workers would not have arisen.

Drs. Gorter and Swart developed the investigation, which we were unable to continue at the time of our original discovery, and found that the sugar was converted chiefly to lactic acid.

The anærobic process for coagulation of *Hevea* latex, together with the necessary addition of sugars in many cases, was discovered and operated originally in the Federated Malay States.

I should be glad if you would insert this correction in your Journal.

Yours faithfully,

B. J. Eaton,

Agricultural Chemist,

Federated Malay States.

7th January, 1919.

NEW BOOKS

ON AGRICULTURE AND ALLIED SUBJECTS.

Everyman's Chemistry. The Chemist's Point of View and his Recent Work told for the Layman, by Ellwood Hendrick. Pp. x+319. (London: University of London Press, Ltd.) Price 8*s*. 6*d*. net.

Manual of Vegetable-garden Insects, by C. R. Crosby and M. D. Leonard. Pp. xv+391. (New York: The Macmillan Co.; London: Macmillan and Co., Ltd.) Price 12*s*. 6*d*. net.

Botany: A Text-book for Senior Students, by D. Thoday. Second Edition. Pp. xix+524. (Cambridge: The University Press.) Price 7*s*. 6*d*. net.

A System of Physical Chemistry, by Prof. W. C. McC. Lewis. Second Edition. In three Volumes. Vol. III: Quantum Theory. With two appendices by James Rice. (Text-books of Physical Chemistry.) Pp. viii+209. (London: Longmans, Green and Co.) Price 7*s*. 6*d*. net.

A Handbook of Colloid Chemistry. The Recognition of Colloids, the Theory of Colloids, and their General Physico-Chemical Properties, by Dr. Wolfgang Ostwald. Second English Edition. Translated from the Third German Edition by Prof. Martin H. Fischer. With numerous notes added by Emil Hatschek. Pp. xvi+284. (London: J. and A. Churchill.) Price 15*s*. net.

Recent Advances in Organic Chemistry, by Dr. A. W. Stewart. With an Introduction by Prof. J. N. Collie. Third Edition. Pp. xx+350. (London: Longmans, Green and [illegible] 14*s*. net.

7. The Science and Practice of Manuring for the Use of Amateur, Market, and Professional Growers, Orchardists, etc., by W. Dyke. With an Introduction by J. Wright. Revised and enlarged Edition. Pp. 157. (London : The Lockwood Press.) Price 2*s*. net.

8. Recent Advances in Physical and Inorganic Chemistry, by Dr. A. W. Stewart. With an Introduction by Sir William Ramsay. Third Edition. Pp. xv+284. (London : Longmans, Green and Co.) Price 12*s*. 6*d*. net.

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11. Agricultural Laboratory Exercises and Home Projects adapted to Secondary Schools, by Henry J. Waters and Prof. Joseph D. Elliff. Pp. vi+218. (Boston and London : Ginn and Co.) Price 4*s*. 6*d*. net.

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13. Mycology and Plant Pathology, by John W. Harshberger, PH.D., Professor of Botany, University of Pennsylvania.

The following publications have been issued by the Imperial Department of Agriculture in India since our last issue :—

Special Indian Science Congress Number of the Agricultural Journal of India, 1919. Price, Rs. 2 or 3*s*.

Bulletin.

A New Nematode causing Parasitic Gastritis in Calves, by [illegible] heather, B.Sc., M.R.C.V.S. (Bulletin No. 86.) Price, As. 4 [illegible]

Indigo Publication.

An Improved Method of preparing Indican from Indigo-yielding Plants, by Bhailal M. Amin, B.A. (Indigo Publication No. 5.) Price, As. 2 or 3*d*.

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2. Scientific Reports of the Agricultural Research Institute, Pusa (including the Report of the Imperial Cotton Specialist).
3. Annual Report on the Progress of Agriculture in India.
4. Proceedings of the Board of Agriculture in India.
5. Proceedings of Sectional Meetings of the Board of Agriculture.
6. Memoirs of the Imperial Department of Agriculture in India :
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7. Bulletins issued by the Agricultural Research Institute, Pusa.
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Proceedings of the Board of Agriculture in India, held at Poona on the 10th December, 1917, and following days (with Appendices). Price, As. 13 or 1*s.* 3*d.*

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