THE REVIVAL OF AGRICULTURE IN INDIA : ITS BASES.

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By.

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A few years ago, following the lead of Ceylon, a number of Agricultural Associations were started in the Southern Presidency, with a central Committee at Madras. They were active in the execution of their self-imposed task, and similar institutions soon arose in different parts of India to follow their example. But, when the first fervour had somewhat subsided, those, who took upon themselves the duty of endeavouring to benefit the people by improvements in Agriculture, began to be appalled by the Herculean labour before them. To raise an inert mass, to change the tenor of life of over 300 millions of human beings, who for thousands of years have moved more or less in the same groove, seemed worse than foolhardy—it appeared next door to absolute lunacy. The people themselves did not want the change. The motive power arose from men who were not agriculturists, and was opposed by the inertia of an immense population. Everything consequently pointed to the hopelessness of all endeavour. Added to this, the most unpractical methods were often resorted to, in order to impress upon the peasants the peculiar views of the various members of the several associations.

In some places "Improved Irrigation" was the cry raised, and oil engines and pumps were considered the royal road to fortune; in others, iron ploughs were the instruments to which would-be reformers nailed their faith; whilst a number, again, seemed to think the Indian farmer did not know the practical part of his business, and required instruction on the subject from men imbured with western science.

At this juncture the Central Agricultural Committee of Madras forwarded to the President of each Agricultural Association with which they were connected a volume entitled "The Organization of Agriculture" by Pratt. No better work could have been issued to meet the exigencies of Indian Agriculture. Unfortunately it was read by few, and misread by a number of these. Co-operative Credit Societies were now declared a veritable panacea.

In every direction imitations of a sort were put on foot of the Raiffeisen banks that are spread over Europe, and Government very kindly came forward with loans to aid the banks to the extent of their subscribed capital. The most important factor in the Raiffeisen banks was, however, omitted. The security taken was that of the individuals and not the property of the whole village, or all the members of the Society, and the Central Bank, the very foundation of an extended co-operative credit, left out of consideration.

Pratt's volume is rather bulky, and contains much that may not be applicable to India. The members of Agricultural Associations are busy men, who have not much time to devote to the study of works by European authors, or to the real wants of the farmers of the country, and it may be useful to lay stress on those pages in the "Organization of Agriculture" which can be applied to this land, pointing out, in as few words as possible, the foundations, already existing in India, upon which a great superstructure may one day be built. As in Europe the beginnings were small of the great Co-operative Credit Societies, that spread a net-work over the whole continent, so in India the poor village partnerships that already exist and the small unions for common objects that can be traced back for ages may serve as the nuclei of the village banks of the future, that will save the peasant from the sowcar and point the way to prosperity and contentment.

But in treating of the Revival of Agriculture in this country it must be borne in mind that combination is a *sine qua non*. Here the pessimists come in with the word "impossible," without giving a moment's study to the subject. Even the optimist admits it will be difficult, and with this most reasonable people will agree. No success worth the having was ever easy. But the difficulties are by no means so great as they first appear. A little study of the villages and village life in India will show so much co-operation existing on a small scale, that the difficulties to be encountered need be considered no greater than those met with in Europe a few years ago.

The watchword then must be "Combine." It is the secret of all success in Europe, America and Australia, and in India will be the bed-rock on which a mighty structure will ere long be erected.

In order that we may be encouraged to undertake so colossal a work as that which lies before us, let us study the beginnings of similar undertakings in European countries.

It will be new to many that the renaissance, if it may be so called, of farming in Europe, began only 25 or 30 years ago, and that the last country to be carried on by this wave of improvement was England.

It will be still more startling and, let us presume, interesting, to watch how from small beginnings great associations arose to do good to untold millions.

Even in Europe passive resistance to all change was at first the rule among the farmers rather than the exception, and it was only after it was proved by experience that there was a positive gain to the cultivator of the land—an immediate and by no means small profit—that combinations of individuals in a village led to associations that spread over whole countries.

A glance at co-operative societies in different parts of Europe will show difficulties likely to be met with and similarly overcome in India.

Let us begin with

BELGIUM.

A Flemish farmer at Goor, went one day to the parish priest M. l 'Abbé Mellaerts and spoke to him about the poor quality of his crops. The curé had studied botany and other kindred subjects at his seminary. He had especially followed up the subject of artificial fertilizers, and he had made experiments on his own account in the garden of his house. So he asked the farmer :— "If I tell you of a remedy, will you use it"? "If it is not too dear," was the reply. When the farmer called again the Abbé gave him a sack containing 50 pounds of chemical manures. The farmer was reluctant to take it. He had no confidence in such a manure as that because it did not smell strong enough. Were these peasants much more advanced than our raiyats? It is not so many years ago that even in Germany a common saying of the farmers, a sort of definition of fertilizers, ran :—"Was düngt stinkt" i.e., "Manures stink." Even at the present day the *credo* of English peasants is summed up in the elegant phrase "Muck, muck, and plenty of it."

The question in Europe is where the muck is to come from, and, if it be difficult to answer in a land where stall-feeding is the rule, what shall we say about a country where animals pick up what they can, and the droppings, instead of going on to the land, find, their way to the kitchen. *Mais revenons a nos moutons.* The farmer was induced to try it as an experiment on a potato patch with such good results that he went to the curé for more. Then several of his neighbours wanted supplies as well. Meanwhile the parish priest had been reading of what the peasants along the Rhine had done in the way of forming combinations for the joint purchase of agricultural necessaries, and he called a conference of members of his flock to consider the adoption of a like scheme for Goor. His parishioners had no great faith in the proposal; but seven of them put their names down as members of a "Peasants' Guild" *just to please him.* The last four words bring us beneath the Indian village peepul tree. The peasants had no faith in combination or co-operation, as is the case in this country, but did not care to offend the *burra saheb*, and were ready apparently to enter upon any scheme, which, in their heart of hearts, they considered sheer folly. But they soon found that they could get their supplies cheaper and of a better quality through the Guild than they could individually, and gradually more members joined. Within the year it consisted of 100 farmers. Considerations of health then compelled M. Mellaerts to remove to Louvain, where he became an active writer on agricultural questions and an especially earnest advocate of agricultural combination. A conference of agriculturists at Louvain, organised by M. Mellaerts and others, followed in July 1890, when it was decided that there ought to be, in every commune in the province, an agricultural association similar to the one at Goor, and that, when formed, all of them should be connected with one central body. By the following year there were 89 local associations of different kinds ready for incorporation into an organization, to which the name of "Boerenbond" or "Peasants' Union" was given. These local associations increased as follows:—

1893	130
1897	349
1900	450

representing upwards of 26,000 members and covering the Provinces of Antwerp, Brabant, and Limbourg. The federation publishes an Agricultural Review, holds a number of conferences and periodical meetings, conducts experimental fields, has a central office from which a vast amount of gratuitous practical advice is given, exercises a useful influence in regard to legislation affecting agriculture, and carries on so big a business in grouping the orders of local associations, that it has organized a separate section for each commodity, set up a mill of its own for the preparation of feeding stuffs, and established a wholesale warehouse of substantial proportions in the City of Antwerp, all this being done in *a little more than twelve years.*

To the original founder of this great federation is further due the introduction and popularization in Belgium of Raiffeisen Agricultural Credit Banks, of which there are close on 200, with about 10,000 members, in direct connexion with the Boerenbond alone.

In 1892, at Ortho, in the north of the Province and in the German section of Luxembourg, the first leagues or syndicates of peasants were established for the purchase, in common, of artificial fertilizers and concentrated feeding stuffs for cattle. Experience soon showed the value of such institutions. The peasants found they could buy, at lower prices, products of a superior quality, guaranteed by trustworthy analyses against fraud. The soil began to produce abundant harvests ; and the cattle, better nourished, improved in quality and gave a richer milk. Confidence in the future revived many hitherto discouraged cultivators. The result of all this was that the people themselves soon asked their pastors to head the movement and create and direct agricultural associations, with the result, that relatively to her size, more associations have been established in Belgium, in the interests of agriculture, than in any other country of Europe.

It is said, with how much truth one cannot tell, that the Brahmin is losing his hold upon the common people. If an appeal to love of country is not successful, if the cry of 'Bande Mataram' proves useless, may not self-interest be a spur to the priestly caste to take the lead in an agricultural revival that, while benefitting the whole population, once more firmly places them in the position they held for ages as rulers and guides of Hindustan? Belgium owes its present prosperous agriculture to its educated priests, who directed their poor parishioners on the road to prosperity, and there is no reason why the educated Brahmin should not begin, continue, and support a movement, that will bring untold blessings to India's teeming millions.

Unfortunately every body wishes to have the support of Government, with the result that little dependence is placed by the people on their own efforts, and, as soon as the prop is withdrawn, the institutions that tottered for a time, with a semblance of life, fall helpless to the ground—very unnecessary proofs of the law of inertia. In Europe we have examples of direct Government aid to the peasant treated with suspicion and ending in failure, while the combinations started by the farmers themselves invariably prospered, and associations for the purchase of artificial fertilizers managed to bring under cultivation large tracts of land that till then had lain waste and could not by other means have been made productive.

The condition of

ITALY,

now a model to all lands for its agricultural associations, was, a few years ago, such, that the change may prove a more fitting object lesson to all engaged in the great work of bringing about an agricultural revival in India. The peasants of Italy were, perhaps, even worse fitted than those of most other countries of Western Europe to meet the crisis that arose when the markets, to which they sent their products, began to be flooded with supplies from the virgin soils of the New World. Italy had then not long attained her national unity, and with it she had inherited a burden of public debts that, poor as she was, crippled her power of action. These were steadily increased under the heavy expenditure necessitated by the altered circumstances of her political position. The burden fell mainly on the cultivators of the soil, and of these a large proportion were owners or occupiers of farms of infinitesimal proportions. There were certain districts in which 25 per cent. of the peasants had less than a quarter of an acre each. In a land as poor as India this statement seems incredible, and if the Bengali with his three acres and the Deccani with his six find it hard to believe what Pratt states to be an undoubted fact, how can we expect the people of Kathiawar to admit its truth, when their unit of land measurement is a Santhi, or 20 acres? But, added to all these miseries, the curse of India was also heavy on them: they were victims of a condition of usury that was little better than slavery. Money lenders flourished throughout the land, especially in the Northern Provinces, by advancing loans to the helpless peasantry at the cruellest rates of interest. In these circumstances it was not surprising that hundreds of the peasants were sold up for non-payment of debts or of rates and taxes, which did not exceed five or six shillings in amount. Translate the coinage and anybody hearing of peasants sold up for non-payment of debts or rates and taxes amounting to four rupees would be ready to swear that the conversation turned upon the poorest parts of India at the present day. Whenever an attempt is to be made to raise the Indian raiyat by means successful in Europe the old song is re-echoed that West is West and East is East. If ever a country was on the verge of hopeless ruin, it was the Italy of the time of which we speak. If ever a peasantry was sunk to the depths of poverty and despair it was the farming class of *Italia Unita*. Yet Italy is a model of agriculture to the rest of the world, and the peasants are prosperous and happy. India is not steeped in such helpless misery as is portrayed above, and why should India not follow similar methods to rise from poverty to comparative comfort? In Italy, under the circumstances related, more and more land went out of cultivation, the numbers of the unemployed in the towns became swollen by the constant accessions from the rural districts, the emigration of those who despaired of their country went on at a greater rate than ever, and, if any country seemed ill-equipped to meet the coming economic struggle for the markets of the world, it was poor Italy. There was only one thing to be done. If they were to compete with the virgin soils of the new countries that poured their cheap produce over Europe, the peasants must resort to improved methods of culture, and must especially make use of the fertilizers that agricultural chemistry was offering to the world, and of the improved forms of agricultural machinery. But to do this meant the expenditure of money, and the problem that arose was: "How can the impoverished peasantry obtain the necessary capital?"

The same two questions require a solution in India at the present day. The land, unmanured but regularly cropped, is getting poorer day by day. The returns are often so low that no European farmer would consider the produce worth the labour. Natural manures are not to be had, and artificial fertilizers must be used. But where is the money to come from? That question was asked in Italy and solved. It rests with India to decide whether Italy's example can and will be followed. Signor Wallenborg established at Lorregia, near Padua, the first of those Village Banks, which have since so powerfully affected the general situation. The Village Banks have a two-fold character. Those known as "Agrarian Banks" are country branches (in effect) of a People s Bank or a Savings Bank, or, alternatively, are affiliated to some central organization, to which the deposits they receive must be forwarded, whereas the "Rural Banks" have complete self-government, and can themselves utilize deposits for the purpose of making advances. In either case the Village Banks can draw on the People's Banks or the Savings Banks, for the funds they may require to lend out to their members. The fear that was entertained in the establishment of the People's Banks that the principle of unlimited liability of members would be impracticable in Italy was dismissed on the formation of the Village Banks, which are mostly based on the Raiffeisen principle, the members of each bank being jointly and severally responsible for any default on the part of a borrower. The effect of this arrangement is that the Savings Bank or the People's Bank, which lends money to the Village Bank, has good security; and the members of the Village Bank, aware of the risk they run, are careful to admit as fellow members, and especially to make advances to, only such individuals as are known to be honest and industrious. A loan would not be made outside a Village, where, of course, each resident would be known to his neighbours. In this way it was found possible to grant loans to men, who, from the point of view of the ordinary bank, had absolutely no 'security' to offer. Moral worth, on which nothing could be raised at a People's Bank, was quite sufficient at a Village Bank; and the losses sustained have, in point of fact, been altogether insignificant. But there were two further steps necessary to make the system complete, viz., an organization to purchase good qualities at a low price, and the best practical acvice to be placed at their disposal in the laying out of the borrowed money. In Italy an official is appointed by a Savings Bank as a Professor of Agriculture, whose function is to watch the progress of agriculture in the district. He is also the director of the local agricultural syndicate, so that, when a would-be borrower seeks an advance from the Village Bank, the professor not only advises the members thereon from an agricultural standpoint, (*loans being granted only for agricultural purposes and not for personal use*), but he arranges for the goods in question to be delivered through the syndicate to the borrower, who himself in no case handles the actual money nominally lent him.

If all this could be done in the Italy we speak of, amongst the poor, down-trodden, Jew-ridden peasants, many of whom had no more than a quarter of an acre to live on, is there not hope for the Indian raiyat, who is certainly far removed from the awful state of misery depicted in the pages of Pratt's volume? Many of the circumstances are so similar that the whole chapter appears like the history of the most wretched villages in the worst States in this country.

Yet, some years ago, there were already 657 People's Banks with 381,000 members in the country and a capital of £4,200,000 and 1,050 Village Banks with 95,000 members and £25,000 capital, 192 Co-operative Agricultural Associations with 45,000 members; and the collective purchases amounted to £800,000 and 750 Co-operative Dairies with 37,000 members and £40,000 capital.

Small, concrete examples appeal more to the agriculturist than figures and great generalizations, and, as in all other European countries, we can show such to emphasize the progress of the revival, which in Italian agriculture, has been called, and rightly so, a resurrection. That a greater amount of land has been brought under cultivation is shown by the town of Sansevero near Foggia, where, in a little over 10 years, thanks to the People's Bank, no fewer than 8,000 acres have been converted into vineyards. And with this there has been a corresponding increase per acre, due to the greater use of fertilizers, machinery, etc.

Whenever we see an improvement in the agriculture of any country in Europe it is found to be due, primarily, to the introduction of artificial fertilizers, to take the place of, or supplement natural manures, and the first co-operative societies formed were started with the object of obtaining such fertilizers wholesale, so that individual farmers could get the best guaranteed article at the cheapest price.

More than any other land India requires associations for the above purpose, for, in many parts not a particle of manure, natural or artificial is, for years together, placed upon the fields. Is it any wonder that harvests grow poorer, and that the people become more discontented, especially when political wire-pullers put the blame for everything, even the poverty of the soil, on the shoulders of the Government? If there is to be a revival of Indian agriculture it must begin with aid to the peasants to purchase manures or artificial fertilizers, without which no improvement in the crops can possibly be expected.

Deep ploughing is much better understood by the natives than agricultural departments are aware of, or will allow; but the knowledge is also not absent that deep ploughing without manuring cannot go on indefinitely without resulting in far greater harm to the land by a falling off in produce as the years go by. The present scratching of the soil is, under present circumstances, the most economical, and the peasant knows it full well. These are probably heretical statements deserving the anathema of those learned people who wish to teach the native how to till his soil: but enquiry in the villages will show that the farmer, instead of being ignorant of the art that brings him his daily bread, is led by the dictates of true science, whence and how handed down it is difficult to tell. Considering the means at his disposal the raiyat is as good a farmer as you will find anywhere in the world, and the man who ventured to say he had little to teach them in this respect would sin in the company of so respectable an agricultural scientist as Dr. Voelcker.

Of course artificial fertilizers could not be introduced all over the country at once. This was not the case in European countries and the story of

HOLLAND

may therefore be of interest to such as wish to see a change for the better here. In Holland, with the fall in the price of wheat, land was going out of cultivation. The State therefore started schools. If this wise measure were followed throughout the length and breadth of this peninsula the Government would be repaid manifold. It is not a course that eventually lands the scholar into the B.A., LL.B., paradise that is aimed at in this country, nor a curriculum that, ending at the Matriculation or the High School Final, ushers the happy scholar within the blessed portals of Government employ. The three R s, to save him from the oppression of the wily sowcar by enabling him to know how his accounts stand, and a simple book on the value of fertilizers ought to meet his needs and enable him to make intelligent use of the reports of progress arriving from other parts of the world.

The Dutch argued that, if the price of the produce could not be increased, it might be turned out at a cheaper rate, or a greater quantity from the same area of land ought to pay. At the same time other articles might be developed. Dairying and market gardening were intelligently pursued to contend with outside competition and against the high rent of the land so circumscribed in its dimensions and kept back by artificial means from the grasp of the ocean. The State taught them how to manage market gardens in the best manner, and the people themselves banded together to sell to the best advantage by means of co-operative societies conducted along extremely practical lines. The goods of the members, before being offered for sale, are inspected by officers appointed for the purpose, and any that are regarded as below the standard are rejected, whilst those that are passed are labelled with the trade mark of the society. Thus approved of, the produce is offered for sale at the society's mart, the auctioneer being generally the president of the local society. The sales are attended by dealers and commission agents from Rotterdam, Amsterdam, the Hague, and elsewhere. The goods sold are paid for in cash, and the money is distributed weekly among the members, each receiving the amount for which his produce has been sold, less a small sum set apart for commission. All that a member is required to pay is an annual subscription of 1*s.* 8*d.* The total sales of the Westland Society amount to about £50,000 a year, mostly fruit. The very essence of this combination is not only that the growers get better prices, especially in dealing with other countries, and not only that dealers can buy produce in bulk, but also that the Railways get regular consignments in car-loads and are able to make lower rates than if they could only expect irregular lots of comparatively small quantities.

There are 11 Agricultural Unions to disseminate information, purchase seeds, manures, and agricultural implements, hold agricultural exhibitions, and establish Agricultural Credit Banks.

Unfortunately for us the difficulties of every European country seem to unite in India to deter even the most energetic of men from the arduous attempt of initiating and fostering the much needed revival in agriculture. Yet in many respects European countries suffered more than India with all its sad experiences.

The bogey of all reform in India is the marwaree, sowcar, money lender, or whatever name the necessary evil goes by. But there were money lenders in Europe who were undoubtedly as great sharks as any the East can produce. Yet, in spite of these, agriculture prospered. The lesson may be of use to the faint-hearted in India.

HUNGARY

is a land whose story ought to be taught to the raiyat turned fatalist. In 1848 the last remains of the feudal system disappeared from the country. As soon as the cultivator had some property, he became an object of interest to the money lenders, who were foreign Jews. (This looks like the story of our friends from Marwar.) They started an inn, (which the marwaree, be it said to his credit, does not do,) and lent money. At a time when they knew that the debtor could not possibly return the money, they demanded full payment, and got possession of the property (again it would be a libel on the Indian money lender to compare him with the foreign Jew settled in Hungary), allowed the peasant to remain on the farm, made him pay rent for house, land, and the hire of the oxen, and thus left him barely enough to keep alive, while the produce of the farm benefited the money lender. This system was carried on principally among the most uncultured Slavs and Roumanians.

To remedy this state of affairs it was absolutely necessary to establish co-operative Banks. Some of the difficulties met with in founding these are such as India is likely to encounter, and, were the name of Hungary omitted from the narrative, the ruses employed to prevent the peasants form shaking off the fetters of the money lenders would certainly be attributed to the least worthy of our Indian Shylocks. Sometimes the money lenders deposited heavy sums with the Banks and waited till the money was all out in advances, and then withdrew the whole sum when it was least convenient to meet the demand, thus gaining their end, viz., the destruction of the Bank. In one village other tactics were resorted to. The leaders of the movement held a meeting of the peasants to induce them to start a Village Co-operative Bank, which the central organization would now be able to support. The peasants took a few days to consider the matter. They soon gave a reply in the negative. Enquiry showed that most of the villagers were indebted to a group of money lenders who had set up a local Bank of their own and now threatened them that, if they agreed to the starting of a Co-operative Credit Bank in the place, they would call in the whole of the outstanding loans. But the propagandists were equal to the occasion. They obtained from the central fund a sum of money sufficient to pay off the debts of the entire village, thus getting the peasants effectually out of the grasp of the money lenders, and they then established the Co-operative Credit Bank, debiting the peasants with the amount paid on their behalf.

It is not sufficient to buy the farmers out of debt. The sowcar is appealed to for seed, oxen, well-digging, weeding expenses, etc., in the course of the year. The debts might, here in India, be compounded for a third, or a quarter of their book value, but *there must be some one to take the place of the money lender*, and that some one must be a Village Bank or a Co-operative Association which must be able to lean on some Central Bank or powerful organization.

The establishment of a Co-operative Credit Bank in Hungary gave such a stimulus to the general movement that, by the end of 1903, there were about 2,000 local Co-operative Credit Banks in the country, and the year's business represented a turnover of some £3,000,000. The peasants also gather weekly and add together the quantities of feeding stuffs they require, and the local officials of the Village Bank arrange the whole transaction for the peasants, obtaining and distributing the supplies, and debiting each purchaser with the amount due from him, if he cannot pay at once. Other agricultural necessaries are obtained in the same way.

If amongst the poor Slavs and Roumanians such wonderful changes could be brought about in so short a time, is there any reason to despair of India? Of course, as long as there is ignorance there will be a certain amount of distrust; but, even where, to the majority, arithmetical figures are but Egyptain hieroglyphics, a *panch* or elected representative society from amongst the farmers is likely to win their confidence, and it is quite possible that the mere honour of having a representation on the Village Bank Committee will induce the peasants to have their children taught in primary schools. Unfortunately in many parts, especially in Native States, it is not the children of peasants who attend the school specially formed for their benefit, but the shopkeepers and sowcars, who fatten on the people, are those who reap the benefit, even in education, from the money meant for the raiyat. But, once a beginning is made on the lines laid down in Hungary, a rapid advance will soon be made.

Agricultural Associations spread rapidly through Hungary and took their guidance from the National Agricultural Society ,which advises its members as to the kind of produce most likely to find purchasers on the markets, gives practical guidance in respect to growing, packing, and despatching, receives the produce in Budapest, supervises storage and sale, and remits the produce of such sale to the producer, less a small charge for expenses. Its turnover is about £22,000 a year. But not satisefid with this, new industries were soon set on foot or organized for the first time. Throughout the country Village Co-operative Stores arose, and Banks, and societies for egg-collection, dairies, and unions for the collection and sale of corn, farmers' clubs, libraries, reading rooms, and model farms.

Yet, as a foundation on which to build all these, there was less co-operation known among these poor miserable Hungarian peasants than can be found in Indian village life at the present day. Here, at least, it is nothing unusual to find a combination of five or six villagers to grow sugar-cane, that each individually could not attempt, nor are we suprised when we see a pan-leaf garden divided among three or four owners in no way related. When we see a combination to draw a water-race from an annually bunded stream it appears quite in the order of things, and co-operation is expected when water is to be raised to a height from a low-lying river to irrigate the adjacent land. Nor is the *gata* or mutual help system unknown, for it is very common to find 5 or 10 raiyats, each the owner of a plough, and a pair of bullocks, form a club to till one another's land. None of this was to be found in Hungary when the revival began, and little of such unions was known amongst farmers in Europe some thirty years ago. Still we hear the complaint from those who have no faith in the future of Indian agriculture, that the raiyats will never be got to combine. In every village, a little study will show co-operation of a sort carried on for ages, and the whole of Kathiawar is known for its Zamph or village fund to pay certain expenses common to the inhabitants. India will soon learn what Hungary learnt. Experience has taught the farmers that, as long as each relied on his own individual power in the disposal of his corn, he laboured under certain distinct disadvantages. He was especially at the mercy of any ring of buyers that might be formed. They knew that if he could afford to keep back his crop for a more favourable market it was practically impossible for a farmer located any distance from the railway to hold his crop until the winter. because he would not than be able to get it to the railway station owing to the state of the roads. To meet the position thus created the farmers, in a number of districts, formed co-operative organizations, which secured loans from the Credit Banks for the construction of corn elevators on the sidings near to some conveniently situated railway station; and to these elevators the farmers could at once send their corn to be stored, the individual lots losing their identity, but, representing on the whole, analogous qualities of grain. By means of these elevators the available supplies could be held any length of time. Not only was the previous difficulty of getting them to the railway station in the winter obviated, but the ultimate collective sale meant the transport of the corn on the railway in bulk, thus effecting a considerable economy as compared with what would have been paid had each farmer sent off his own particular lot as a separate consignment.

To bring about such a union for the purpose of selling the year's produce in common ought to be no difficult matter in the Native States in which, to the present day, payment is made inkind or partly in cash and partly in kind ; for the people are accustomed to the stacking of their harvests in the common granary, and, unfortunately for themselves, know the meaning of a delay in the sale, not for the purpose of obtaining a higher price, but to meet the convenience of the Revenue Officers.

Notwithstanding the examples here given of the difficulties in Europe very similar to such as are found in India, overcome at last by the people, there are numbers who will still persist in saying that union will never be effectual in an Indian village.

To such, one must mention the case of

SWITZERLAND.

A considerable expansion in the industries of Switzerland between 1870 and 1880 led to a steady flow of population from the country to the towns, and the shortage of labour became marked. It was necessary, therefore, to resort more to machinery in order to solve the labour problem, and to the use of artificial fertilizers in order to increase the volume and decrease the relative cost of production, so as to compete better with the foreigner. To establish an organization was therefore a matter of life and death to the Swiss farmer. But it took a long time for the peasant to work himself up to this conviction. An incarnate individualist, he resisted any idea of actually resorting to combined trading or co-operative effort, even when already convinced of the necessity of so doing. Finally, however, he saw it had become for him a question either of combination or of ruin ; either of rising to a true sense of his position and showing confidence in his neighbour, or of dropping out of existence. When once the alternative presented itself mercilessly to the Swiss peasant, he applied himself with good spirit and a lighter heart and also with a skill at which we cannot fail to wonder, to the development of a great system of organized action.

The actual pioneer of the movement was a certain landowner in Raterschen, (Canton Zurich), who had purchased, wholesale, a large supply of chemical manures, on much lower terms than his neighbours were paying. This opened the eyes of the farmers to the benefits to be derived from wholesale purchases, and to the necessity of combination for the purpose. In 1874 an Agricultural Association was formed to secure such advantages. But though local organizations increased, it was only in 1881 that a district federation of these was formed through the active exertions of a young parish priest.

Here we have the wealthy landowner and the religious leader combining to help the people to rise from their misery and their aloofness from one another, to combine for the common benefit. Is it too much to expect something similar from the Hindu rais and the local representative of the parish priest ?

Again, the very serious objection may be raised that the peasant is too ignorant in this country, and that therefore no hope lies before him. Alright. Let this be conceded for the sake of argument. It will be brought forward by the educated classes. This enables an appeal to be made to them, and, that the impossibility of helping the farmer may not be advanced as a shield, by these men, against the blame cast upon them for inaction or indifference, a reference will be made here to what was done by the University students in

FINLAND.

These young men, pursuing their studies at Helsingfors, flocked to the lectures on agricultural subjects and, when they returned to their homes, even for the holidays only, became propagandists of the agricultural co-operative movement.

Is there not a society, established somewhere round Poona, with ramifications all over the country, the members of which are sworn to spend their lives in the service of India? Can there be a greater service done to the land they have sworn to serve than the introduction of the co-operative credit societies to free the peasants from their burden of debt, to enable them to purchase the sadly-needed manures for their fields, to help them to band together for the purpose of lessening their expenses by wholesale purchases and increasing their earnings by combined sales of produce, in fine, to teach them to unite for a common purpose, which immensely benefits each member and the whole community?

In England, co-operation in Urban centres, in manufacture, and in the purchase and sale of goods, has been in existence over half a century. It has been only lately, however, that *agricultural* co-operation has been started in the British Isles.

The Agricultural Organization Society in Ireland owes its origin to Sir Horace Plunkett, and now there are the following co-operative bodies in that little island :—

Creameries		331
Agricultural Societies		151
Credit	,,	232
Poultry	,,	25
Flax	,,	9
Industries	,,	50
Beekeepers'	,,	18
Bacon-curing	,,	7
Miscellaneous	,,	13
Federation	,,	4
	Total	840

These societies turn over 3 crores of rupees, a respectable sum for so small and so poor a country, and the banks, though they have advanced about 37 lakhs, have suffered no loss. The result has been the reduction of the price of artificial manures by about 30 per cent. and the cost of seeds and agricultural implements has been lowered considerably, a fact which could not have been accomplished but by co-operation. It has also been an education to the people in thrift and business habits

In England the Agricultural Organisation Society is only a few years in existence, but it has affiliated to it no less than 15 Agricultural Credit Societies, 118 Societies for the supply of requirements and the sale of produce, and numbers of others, totalling 185. The increase has been rapid. There were 25 in 1901, 98 in 1904, and now nearly 5 per cent of the farmers in the country are members. Sales are made at a higher price than could possibly be got by the individual members, and purchased goods obtained considerably cheaper.

With similar institutions a far greater saving could be made on each petty article required in an Indian Village, for purchases, made on an infinitesimal scale and on credit from the local bania, are naturally far from cheap. Take such a thing, for instance, as the small, but ever necessary supply of kerosene oil, and compare the price paid for the requirements of the little *buttee* with the charge of the same when a case is bought, and it will show pretty clearly that, though the villager's wants are few and small, he must pay heavily for every little item bought. Yet it is not descending to unbusiness-like trifles when we consider such small matters, for in a country like England even the smallest articles that bring in an income are considered. The Framlingham Society sold more than a crore and a half of eggs, obtaining for them 25 per cent. more than was formerly got from the middleman.

The Caermarthen Farmers' Co-operative Society gives us an idea of what is being done in Wales. In four years it numbered 600 members, turned over £27,000 and reduced the price of feeding stuffs from 10 to 15 per cent., of seeds 20 to 30 per cent., and of artificial manures 30 to 40 per cent.

At Eday in the Orkneys, North of Scotland, the poor crofters, with a capital of Rs. 198-12, have gained over 12,000 Rupees. So that poor as Indian villagers may be, there is every prospect of good being done if the people will only combine.

Once co-operation has been tried on a small scale with the introduction of Village Banks, industries will spring up like magic throughout the length and breadth of the land.

There is no need to refer to the creameries of Denmark, of Norway and Sweden, and of Ireland. It is bad enough to find such immense imports of sugar into a land that ought to supply the rest of the world, but it is almost unintelligible, in a country where ghee is a necessity, that decent butter is so little obtainable as to necessitate the purchase, by Europeans, of such an article from Denmark, at a price cent. per cent. above what would be a handsome profit in India itself. Worse still, the clarified butter sold in this country is so adulterated, especially in the large towns, that the cry has been raised for a food adulteration act. It is not uncommon for people in the Madras Presidency, though they hear the cry of *pal*, as milk is offered at every railway station, to obtain their butter from the Bombay Dairy Companies. It is time for patriots to drop noisy politics for a spell and to attend to the material wants of their 300 millions of fellow subjects. They can benefit their country far better by educating the people to a true Swadeshi, which must bring in its train a real advance all along the line. The necessity and the utility of combination ought to be apparent as the foundation of all agricultural progress and power.

If, in British territory, owing to the hard and fast lines requisite in the government of the country, the establishment of Raiffeisen banks in a few villages may not be so easy, a commencement should not be difficult in some of the various Native States. In these, on a small scale, and in a few villages, the State may act as the

Central Bank, Village Banks may be attempted, concentrated fertilizers purchased, and agricultural associations formed. These small organizations united, the community may, in course of time, hope to accomplish anything that the history of the Revival of Agriculture in Europe has shown feasible by a determined united peasantry.

But even in British Territory in India a very important means can be used to bring about an agricultural revival and that is the Indian Army. The company gardens, once so well known in cantonments, but certainly not appreciated by men enlisted from towns and cities of England, would probably be very much appreciated by the Native troops, coming from the land and accustomed to work in the fields, and should form part and parcel of the agricultural classes that should be established. There is nothing strange or ridiculous in the idea, for it has been carried out successfully both in Germany and in Italy, and more good would be done in this manner and the benefits of scientific agriculture more widely spread, if, at centres where large bodies of Native troops are stationed, a class were formed to point out the newest things science has to tell us about the cultivation of the soil. The first principles of the formation of soils and the consequent differences in fields, the plant foods taken up from the acre by various crops, the preservation of cattle manure, and the necessity for certain regulations to enable bacteria to do the work of maturing the farmyard manure, the value of natural and artificial fertilisers, and the proper method of conducting experiments—these would prove a sufficient foundation for earnest work on the part of the scholars, when, on leaving the colours, they returned to their fields scattered all over the continent. Nothing would help the spread of agricultural education more than this.

Instead of building the educational structure of Agriculture from below, beginning with elementary training, and advancing by stages to the High Schools and Colleges, as is done on the Continent, we begin with and confine agricultural education to Colleges.

In the 'Practical Adviser', a Weekly Supplement to the Westphalian Volksblatt, issued on the 8th March 1909, we find the following taken from the German 'Weekly Military News':—

"Instruction in agriculture is now to be introduced throughout the Army after having been fostered for two years among the troops in Bavaria. Last year 6000 men attended the school, while a great number of applicants had to be refused owing to want of room. In Italy this Institution has been in existence for ten years and the number of scholars attending during the last 12 months was 56,000 It is said of the students that, on leaving the colours and proceeding to their homes, they form crystallising points for agricultural associations, and for progressive agricultural education. The agricultural courses have been so well attended and have created so lively an interest in Germany, that they appear to supply a real want, and they point to the earnest endeavour of the agricultural population to seize every opportunity to widen and increase their horizon of knowledge and experience. That young men of 20 to 23 are especially drawn to this, requires no discussion, for we see the fact that the broader views obtained by recruits and soldiers in the barracks seem to urge them on to attending these classes. Of course the curriculum is not exactly a preparation for agriculture, but a number of practical points can be studied in these army schools, which will amply reward attendance at them. It will perhaps interest a large circle to know that Germany imports one and a half milliard marks worth of agricultural products that could be produced in the country, and those who attend this course of studies should have the fact brought home to them to stimulate them to bring about a production of this in Germany itself."

The day has gone by when the farmer could say contentedly :—" My father before me and his father before him could neither read nor write and they got on well enough as practical cultivators. Why should I need more than they to carry on my work satisfactorily ?" The answer is simple enough. The rest of the world has not remained stationary even if Indian farmers choose to do so. It is a long time since the railway train arrived to take the place of travelling by cart, horses are now making room along our roads for motor cars, and steam itself is giving away before electricity. Everybody else in life sees the necessity for study, and the ordinary routine of learning has to be vastly changed to suit the modern necessity of specialising. The European farmer has seen the necessity not only of combination and co-operation but of studying hard everything connected with his business. He is no longer satisfied with the facts he sees before him, but he studies their causes and effects, the why and the wherefore of everything connected with his farm. It is true the great competition with America, North and South, have forced this upon him. But are we in India quite outside the effects of this competition ? Decidedly not. India's produce has no small place upon the world's markets, and whatever influences this tells upon the wealth of the country and the well-being of the farmer. If Germany feels seriously the competition in wheat brought about by the immense supplies forwarded to Europe by Argentina, will not the fall in prices tell against India when that South American country's immense resources are further developed ? If the price of wheat is lowered the Punjab peasant must produce more on the same acreage, if he is to live at all. To do this he needs study, as the European farmer did under the same circumstances. And there is a great deal more to be learnt than the cultivator of this country dreams of. To work his plough, he must be a good judge of the cattle he buys, and that alone is a science of which he does not know over much. If he wishes to get the most work out of his animals at the least expense of wear and tear, he must know the value of various foods, and this means a little chemistry. The very plough he uses may or may not be the very best ; but he must study others before he can be a judge, and learn whether the strength of his animals is being wasted or money lost by continuing to cultivate his land in the manner his forefathers carried it on 4,000 years ago. Some knowledge of mechanics is required for this. For irrigation he may require the study of pumps, for manures a knowledge of certain chemical plant food constituents, and for an idea of soils, both chemistry and geology. During seasons of too much rain a little engineering for the proper drainage of his land will not be out of place, and in seasons of drought some meteorology would not be out of place to help him to conserve the little moisture left. When sickness attacks his plants he might be able to trace the cause if he knew some entomology and bacteriology, and, by their aid, get rid of the danger to his crops, and at all times his mind must be ready to note cause and effect and be prepared with prevention and cure. If everyone else must prepare himself by study to follow even the most practical career, such as mechanics, is the farmer alone to find himself successful by tumbling into his father's shoes, or learning "mukee ke mukee" what his father did, without the faintest notion as to why the things were done? The merchant who is to be successful now-a-days studies trade. The farmer is also a merchant, or his crops would be useless. He must study Geography to learn where and what is grown that may compete with or take the place of the crop he raises, and he must make himself acquainted with the rise and fall of the market, and the best times and places for buying and selling. This looks like a demand for a knowledge of all the sciences; but though no very deep study is required for each, the successful farmer needs a general knowledge of all these subjects. Yet so many of our Indian farmers who cannot even read, think themselves cleverer than the rest of the world, even though they cannot cast accounts. Are such men going to compete with the farmers of the rest of the world? Already sugar is pouring into India, though this country should supply Europe. Were the white sugar imported replaced by gul or jaggeree, how long would sugar-growing in India last? It will be the same in course of time with the various cereals, and it will be a sad day for the country if it awakens to a necessity of study, only when the terrible pinch of competition has reduced agriculture to an industry that does not pay. Of course we cannot expect the farmer to study all these subjects atonce. But, when the three R.'s are mastered, and combination and co-operation begun in our villages, the day will not be far distant when a demand will be made for an education such as will fit the people to fight the battle of life in which success will be reached by the fittest. The Americans know the value of agricultural education and they see the results of scientific farming.

What can be done by intensive culture, whether it be tillage, or sheep and cattle farming, is patent from the fact that in England, about the middle of the last century, a farmer with 250 acres secured a net income of Rs. 1,800 a year and there were farmers whose revenue ranged from Rs. 7,500 to Rs. 15,000. And no wonder, when we bear in mind that it was the aim of the cultivator to produce 60 bushels of wheat and 100 bushels of oats per acre. It should be remembered that land pays the farmer in England, though the labourer gets Rs. 60 a month during the Summer and Rs. 36 to Rs. 45 during the Winter; but he does a good day's hard work to get these wages. Yet the English farmer was not, till lately, a student of books. He read his Agricultural newspaper, and met other people at the fairs amd markets where ideas were exchanged. Conservative by nature, he did not reject a thing because it was new. As soon as he found a thing would pay he adopted it, for he was a man of hard common sense. Thus it is that his land, by the use of manures, has become exceedingly fertile, and his cattle by careful selection and feeding, are renowned all over the world. Since then he has found that the study of books helps considerably. We must also learn, whether it be from books or neighbours, of what is done in other countries, not to appear more learned than our neighbours, but to consult with them as to the best means of improving the soil and the harvests. And for this nothing is better than a careful study of what has been successfully done elsewhere for years. Despise nobody, learn from all. Let our Motto be "Science with practice," and with our small wants we shall soon be comfortable, if not actually wealthy.

The objection may be raised that 100 acre holdings are rare. So they are in France, where 4 million holdings are under 10 acres. A quarter of the average cultivated land in Bavaria is divided into 2½ acre plots, half the holdings are under 25 acres and only 1 in 1,000 is larger than 250 acres.

If we have in India all the difficulties combined from which European nations suffered at the time of the Revival of Agriculture, we have also got many advantages unknown to them, especially the village system of government that has remained while invaders came and went, and dynasties changed, turbulence reigned supreme, and life itself was unsafe. There have been, with the village system, from time immemorial, a number of co-operative schemes in existence. These want only development, and, with a little education and adoption of means successful all over the world, there is every reason to prophecy a revival that will make India a marvel to the rest of the world, when wealth will pour in as the land is developed, and manufactures follow upon the improved status of the peasant. With the arrival of the Village Bank and the withdrawal of the Sowcar let us hope that day is not far distant.

People may also say that the need for intensive culture is not yet felt in India, that competition in the European markets rarely affects the agricultural products of the country, and that there will be time to imitate Europe, when the pressure is felt here. The misery caused by the unpreparedness of the European farmer, when America flooded his markets, must be realised by those who bring forward this argument, if they are to appreciate the awful consequences to India of such a delay. Even if no danger of such competition appeared above the horizon, it is an extraordinary way of endeavouring to benefit the raiyat and the country by allowing agriculture to continue showing such poor results. When the acre of wheat produces 9 bushels against 32 in the United Kingdom, and the cotton harvest 68 lb. against 190 lb. in the United States and 385 lb. in Egypt, it is time to consider what improvement can be made without waiting to be spurred to it by a complete loss of the trade in these commodities. But are we so free from danger from outside competition ?

In England a Royal Commission was appointed in 1876, to enquire into the depressed condition of agriculture and its causes. The final report was published in 1882 describing distress of unprecedented severity and attributing it to a "succession of unfavourable seasons, increased foreign competition, the increase of local taxation, cattle disease, and other causes."

In 1893 another Royal Commission endeavoured to ascertain the cause of the continued depression among the agricultural classes, and the conclusions they arrived at were that, with the fall in prices, the value of land had sunk about 50 percent. In 20 years cereals had fallen 40 per cent., and wool, dairy produce, and potatoes had fallen from 20 to 30 per cent. And all this was due to foreign competition.

If this could occur in a land where the cereal harvest is above 30 bushels, have we nothing to fear where 10 bushels is the average return ? Is the day far distant when prices will be so depressed by foreign competition that a wail will be heard throughout India? The steam ploughed prairies of Argentina, the United States and Canada, must ere long glut the European market, Continental sugar backed by science, may even replace our Indian gul, African cotton, in the no distant future may lower the value of our cotton fields, and then God help the Indian raiyat.

Intensive farming must be resorted to, and a regular system introduced of rational fertilizing. The farmers must unite, must co-operate, if only to save themselves, or they will soon learn the full meaning of the phrase "United we stand; divided we fall."

Our returns are practically stationery. Such is not the case with the progressive countries of the West. In 1800 less than 156,000 bales of cotton were produced in the United States: in 1910 the harvest was 11,500,000 bales. In 1840 the maize grown amounted to 378,000,000 bushels: last year it was 3,046,000,000. Wheat has increased from 85 million to 670 million bushels in less than 70 years. The present rice produce is 24,368,000 bushels, and linseed .5,856,000 bushels. How far all these may still rise, and, by lowering the market value. prepare the ruin of India, no man can foresee.

A few figures showing the rapid advance in exports, by Argentina, of agricultural products raised in India may open our eyes.

The following article translated from a German agricultural newspaper will give an idea of the rapid progress of Argentina and the light in which it is considered in Germany.

"*The competition in Argentina wheat this year is of very great importance even to Germany, as it is quite evident Argentina is prepared and is in a position to fill the place left vacant by the falling away of exports from the U. S. of America.*

It is scarcely 30 years since Argentina wheat came upon the world's markets. In 1876 the total exports from that country were 22 tons from a harvest of 300,000 tons or rather less than ½ per cent. of the world's crop. The culture of wheat has gone up by leaps and bounds since the eighties.

In 1872 the area under wheat in Argentina was 130,000 hektares; in 1904 it reached 4,5000,000 hektares. In the same year land under wheat in Germany amounted to only 1,920,000 hektares, and Argentina had sent out 18 per cent. of the world's wheat exports.

Slowly, but constantly and steadily, the culture of this crop is going southward to a more moderate climate and Buenos Ayres is now the centre of the wheat growing district, 5° South, instead of Santa Fe, which ten years previously had been the chief mart. For the next 20 years we must expect ever increasing expanses to be brought under wheat cultivation, and a corresponding export to follow. All the Argentina landowner has to do at present is to use a steam plough on the land and scatter his seed. By the time the wheat crop begins to dwindle, alfafa will be sown for his herds of cattle. How Germany with its artificial manures can compete, it is impossible to tell, for it will pay Argentina to export when all chance of profit has come to an end in Germany.

With a harvest of 3,689,000 tons Germany produced in 1904 only 4·81 of the total of the world's wheat harvest."

It is not in wheat alone that competition is to be feared.

Exports of linseed were :—

	1907.	1908.
India	335,214 tons	162,830 tons
Argentina's	831,887 ,,	1,082,264 ,,

To give some idea of the rapid increase of agricultural products in lands lately brought under cultivation, it will be sufficient to quote a few figures stating the increase of wheat growing in three Provinces of Canada :—

AVERAGE UNDER WHEAT.

	1901.	1906.
Manitoba...	1,965,193 acres	2,721,079 acres
Saskatchewan.	487,170 ,,	2,117,484 ,,
Alberta...	43,103 ,,	223,930 ,,

Yet of the total land area of Canada viz. 858,608,837 acres, according to the Census of 1901, only 63,422,301 were occupied, and the rural population amounted to no more than 3,350,000.

Between the great lakes of Ontario and the mountains of British Columbia lies an area of over 600,000 square miles having a population at present of about 800,000. It is essentially a wheat-growing country, probably the greatest continuous area of its kind known in the world. With only one-sixth of its area in wheat it would produce a quantity equal to one-half of the present world's production.

Railroads are being built in many directions, and new areas are being opened up every year. The population is growing rapidly.

In	1881	it	was	only	43,228
„	1891	„	„	„	219,305
„	1901	„	„	„	419,512
„	1906	„	„	„	808,863

Canada's nine provinces measure 1,400,000 square miles and the unorganized, and partially explored land is no less than 2,100,000 square miles. Only about 3 per cent. of the entire area is as yet occupied. In a few years the occupied area will be increased many times over.

In South Australia though a yield of 7 bushels is financially as satisfactory as one of 15 bushels in New South Wales, or 20 bushels in New Zealand, the cost of growing wheat being phenomenally low, the people see that more can be gained, and of 2,000,000 acres under wheat in 1906, 1,321,000 were artificially manured against 60,000 acres ten years previously.

The wheat belt in Australia produced from 5,978,000 acres in 1906-07, 66,100,654 bushels.

The output of wheat had tripled in the preceding 15 years.

The area under maize in 1906-07 was 325,581 acres yielding 10,175,000 bushels of grain.

For hay-making with wheat and oats 864,200 tons were used, the growth of 591,771 acres.

Hitherto settlers kept to one line such as wheat-growing, sheep and cattle rearing, dairying, etc. The reverses of a few years back have brought about fuller recognition of the fact that mixed production is the surer method.

Queensland once put 14,000 acres under cotton, and, though the industry languished, during the last 2 or 3 years attempts at a revival of cotton culture have been made, and once they succeed we will have a formidable competitor. Africa is already on the lists against us. Their cotton, which is a better staple than ours, may yet render Indian lint of next to no value.

When the 9 bushels per acre of Russian wheat become 30, not much wheat will be exported from India.

What may yet be expected from China, if a revival takes place there, it is impossible to conjecture. But, that India will suffer, there is not a shadow of doubt, unless a rational system of fertilizing is introduced to obtain, from the same area, returns so much greater, that the increased production will more than compensate the fall in price. The experience of Europe a few years ago will soon be the experience of India. It behoves us then to benefit by the means used in Europe to combat the fall in prices, and to avoid the evil by preparing against it in time. Whether the present fatalism or indifference is due to ignorance of the world's history of the present generation or not, it is necessary that the educated classes should bring these lessons home to the Indian peasant or the whole country will suffer the terrible results impending.

The enormous figures of harvests from America and the wealth they bring into the country should act as a stimulus, to all true lovers of India, to urge our raiyats to imitate the intensive culture of the United States.

In Munsey's Magazine for December 1910, we read :—

" As a nation, we are again blessed with abundance in the matter of the harvests. The total wealth drawn this year from the soil of the United States, including crops and animal products, is estimated, in round figures, at nine billion dollars. There is no serious shortage anywhere, while on the other hand we have record—breaking yields of at least two important crops—corn and oats. We have the fertile fields, and we have farmed them with success.

Although it is even yet too early to give the definite totals of every corp, the harvest season has progressed far enough to make possible close approximations of all the most important staples. Here is the basis of our prosperity as a nation, the record of the harvests, given *in quantities and in farm values, and comparing the results of this season with the results of 1909.*

	Quantity, 1909		Farm Value, 1909.
Corn ...	2,772,376,000 bushels	...	$1,628,822,000
Wheat ...	737,189,000 ,,	...	730,046,000
Oats ...	1,007,353,000 ,,	..	408,174,000
Barley ...	170,284,000 ,,	...	93,971,000
Rye ...	32,239,000 ,,	...	23,809,000
Buckwheat.	17,438,000 ,,	...	12,188,000
Flaxseed ...	25,856,000 ,,	...	39,466,000
Rice ...	24,368,000 ,,	...	19,341,000
Potatoes ...	376,537,000 ,,	...	206,545,000
Hay ...	64,938,000 tons	...	689,345,000
Tobacco ...	949,357,000 lbs.	...	95,719,000
Cotton ...	10,609,668 bales	...	129,537,500
Cottonseed.	5,181,500 tons	...	129,537,500
	Total	...	$4,879,857,595

	Quantity, 1910.		Farm Value, 1910.
Corn ...	3,046,000,000 bushels	...	$1,523,000,000
Wheat ...	669,533,000 ,,	...	627,352,000
Oats ...	1,055,466,000 ,,	...	379,967,000
Barley ...	151,726,000 ,,	...	85,118,000
Rye ...	32,088,000 ,,	...	23,360,000
Buckwheat.	15,500,000 ,,	...	11,005,000
Flaxseed ...	17,066,000 ,,	...	39,935,000
Rice ...	28,000,000 ,,	...	25,200,000
Potatoes ...	300,905,000 ,,	...	204,014,000
Hay ...	60,374,000 tons	...	713,621 000
Tobacco ...	940,000,000 lbs.	...	94,000,000
Cotton ...	11,500,000 bales	...	825,700,000
Cottonseed.	5,750,000 tons	...	172,500,000
		Total ...	$4,724,772,000

But the very first step to aid the Indian raiyat must be the establishment of a Central Bank, such as that proposed by the Honble Sir Damodar Vithaldas Thackersey. The question then arises as to the distribution of the money from this central source, which acts as a great reservoir, from which canals will carry the necessay water to the parched land. The security is there in sufficiency, like fertile land which only a waits the supply of credit to make it fructify and bear hundred-fold crops. When treating on this subject the various ends for which banks have been and are established do not require consideration. The question here concerns the establishment of Agricultural Banks only, meant principally for loans to cultivators to help them with funds, when most necessary, with the object of enabling them to get the best profits from their lands. Such will always require careful and conscientious management; but as they are likely to be small, and restricted in the area on which they depend, the risks run will also be few and trivial. Yet upon these, to a very great extent, will depend the future wealth of this vast continent.

Here we will consider two sorts, common in Europe, and see which is more likely to be easier worked and more profitable to the shareholder, the peasant, and the country.

Both have for their object the supply to agriculturists of cheap and sufficient capital, and both are run on the co-operative principle. Both educate those who participate in the profits obtainable from them, both may be of use in this country, and there is no reason why both may not be successfully carried out.

It is the want of security that, to a great extent, is the cause of usury in India as in other countries. Given a reliable security, there ought not to be a difficulty in obtaining credit. Further, this credit, especially among the very poor, must be brought to the farmer's door. An ordinary bank would find almost insuperable difficulties in ascertaining the solvency and credit of small farmers, and might reasonably object to be burdened with land in out-of-the way places for payment of debts. With rural banks there is not much danger of failure to repay loans, for the persons to whom loans are made are thoroughly will known in the district, and the mere fact that personal security is required brings a powerful influence to bear on the return of capital lent together with interest.

Of the two systems under which most co-operative rural Banks mav be classed, the Schulze-Delitzsch, modified by Luzzatti, will probably be useful to the comparatively few, who have a fair amount of land and substance but often stand in need of loans to tide over difficult times or to effect improvements, while to the vast majority in India the Raiffeisen system will be more beneficial, though, till it is understood, capitalists may not be inclined to give their aid, under the impression that philanthropy is required, which they consider a poor investment in this world, however paying it may be in the next.

We shall therefore consider these systems separately and see how far each singly, or both combined, will act towards the regeneration of Indian agriculture.

The difference in the systems, however much their principles agree and their results are similar in communities of different degrees of wealth, or rather poverty, appear in their very formation.

To start on the Schulze-Delitzsch system.

(1) a fair amount, or what would be considered such in India, is required :

(2) loans are made to the individual members only.

So far the system and its Italian modification agree.

The questions on which they differ are—

(*a*) the minimum price of the shares, and

(*b*) whether liability should be limited or unlimited.

To safeguard all credits ordinary security is taken, to which is generally added personal security, and for this purpose the Bank requires a regular private book in which is entered the assessed credit value of each member.

This of course must be secret. The acceptance of Bank shares as security may prove dangerons, for the bank may, in course of time, be left with the greater number of its shares in place of the repayment of its loans. The most careful checking of the management by a committee is required. Where these smaller Banks belong to a larger Union, further supervision on the part of the Union becomes a necessity.

These banks have been very useful, and, not being restricted to the financing of agriculture alone, have done an immense amount of good to agriculturists and non-agriculturists alike, wherever they have been established in Europe.

When started in populous districts where poverty is not grinding and the necessary checks are ever ready, they prove prosperous undertakings to the members, who must be shareholders.

Whether, and how far, they would suit Indian villages, is another question.

The Raiffeisen system appears one much better adapted to the circumstances of our peasants, and is the one hope for the general revival of agriculture in India.

Its aim has been described as philanthropic, but there are many examples of philanthropy well-regulated, that pay exceedingly well, and there is every reason to hope that true patriotic philanthropists will obtain the ends in view, whilst showing good banking profits and proving themselves good business men.

By this system we tap a security hitherto unrecognised, yet of such proved value, that immense sums of credit have been obtained on it all over Europe, viz., the honesty and capacity for work of the individual, and his neighbour's belief in it to the extent that he is ready to pledge his credit as further security for the return of the loan.

Here we have to start a Bank for the benefit of the very poor, burdened in many cases by debts upon which the interest of usury has to be paid. Such people cannot be asked to combine their capital, which is non-existent, in order to help one another by the combination. They want the means to be relieved of the awful drain upon their resources occasioned by heavy interest paid often upon ancestral debts, and the help to start afresh. The business of each particular Bank may be small, but the large number that can be financed by a Central Bank will bring in a steady, and, in India, a by no means small return for the capital expended.

No shares are to be bought, no entrance fees paid, and, for security, all who agree to be enrolled as members must bind themselves individually and collectively to pay for the loans and interest not returned to the Bank by borrowers. Wherever there are small communities rooted to the soil, as is the case all over India, every one in the village knows the character and means of the others, and no village committee will be so foolish as to lend money, for which they are responsible, to any member of the community likely to squander it. Naturally no one will be admitted to the privileges of the Bank unless sobriety, and honest and hard work enforce confidence in his character. In every Indian village there are numbers with no better security to offer, who could rise to comparative wealth, provided they were relieved of the incubus of the money lender, and supplied with the necessaries, especially manures, required in intensive cultivation. Wherever garden crops are grown there is security sufficient for any Bank, and the dry crops of each year, not one of famine, will repay at the end of each season the money advanced on them, if the raiyat can only manure them. But it is not of the advantage of the Bank to recall the whole sum advanced in money or otherwise at the gathering of the crop. The profits to the farmer will not be large enough to show the great advantages of the system so soon. Easy payments would encourage the peasant to put his profits into the farm, and thus, increasing his returns, further encourage him to more intensive culture and rational manuring, which has been the salvation of the peasants of so many countries of Europe.

The Central Bank should first ascertain the number of villagers in each little community upon whom they can rely, and to what extent their security is satisfactory, and obtain from them the security of each and all who wish to benefit by the Village Bank, and then the necessary loan may be advanced, and placed in the hands of the elected committee. Loans to individuals are not the concern of the Central Bank. Even when loans are made they need not necessarily nor generally be made in cash. Manures, implements, etc. can be supplied after being bought cheaper and better by the committee than the individual borrowers could possibly have purchased them. The same plan is carried out in many parts of Europe, and may be very necessary when unusual sums of money reach the hands of otherwise careful steady men.

The security is consequently far greater than the tagavi loan advances of the Government can show.

As an example of what may be done by timely aid in the shape of money advances at a low rate of interest, we have only to look at the Nera Canal Scheme Tagavi Advances. Here Government came to the help of the sugarcane growers with advances of Rs. 474,315, between January 1908 and June 1909. As Government required their $3\frac{1}{2}$ per cent. net on the loan, and the usual Government management is not, as a rule cheap, the farmers were charged 9 per cent. A business concern, not dealing with individual borrowers but lending to the village on the security of the community, could have obtained 7 per cent. and 2 per cent. would have been ample for the further working of the loan scheme by the responsible farmers helped by a good accountant. And though the Bank got 7 per cent. in interest, the money would reach the peasent at the same rate at which they got it as tagavi. Of the 4 lakhs odd advanced, Rs. 2,07,815 were loans against crops due for crushing between October 1909 and June 1910, so that the report deals with Rs. 2,66,500, with interest till June 30th 1909. The actual amount recovered was Rs. 2,25,689, and Rs. 18,395 as interest. The remainder stood over against a further crop, where failures had taken place, and the loss to Government was nil.

In this scheme the element of risk was not small, as loans had to be made to individuals by a Government officer, who certainly could not have so thorough an insight into the character and means of the borrower as the members of the villiage communities would have ; nor could he supervise as carefully the use made of the loans received, as would be the case when the community were held responsible for the repayment of the debt. Yet in this case we not only see the loans repaid, though probably 75 per cent of the villagers were at the same time indebted to the local bania or marwaree, but the very first investment made on the receipt of the loan is found to be a purchase of oilcakes, fish, and other manures employed extensively for fertilising so expensive a crop as sugarcane. The co-operative system of purchase and sale was at once understood and appreciated by the villagers, for Government bought fertilisers in quantity and cheap and retailed them at wholesale prices to the farmers, besides selling the produce for them.

Though 50 per cent. of the money advanced produced a net profit to the raiyat of less than Rs. 150 per acre, a not very handsome return when the long waiting is taken into consideration, yet in 28 cases, or 11·2 per cent., the profits per acre ranged from Rs. 300 to Rs. 600, enough to make wealthy raiyats in a few years of such who obtained, by loans, the means to show their skill in intensive farming. Unfortunately we have no returns showing the exact amount spent in each individual case on manures, an item which would have proved of absorbing interest to those who might wish to introduce village banking on the Raiffeisen system, and of very great importance when the consideration of short loans for rapidly maturing succeeding crops is taken up by the practical business man.

Where not much cash is advanced but the farmer's necessities are supplied, on account, by the village banking committee, not only are still fewer risks run, but loans are still less liable to be abused, a spirit of co-operation for purchases and sales is started, and a real education in thrift given to the whole village, agriculture benefits a great deal more by the keen interest taken by all in the success of individuals. more land comes under better cultivation, and the indebtedness, that has hitherto hung like a millstone round the neck of the peasant, will be removed once for all. With the tagavi advances a loan beyond the limit of a year, which may or may not be one of bumper crops, is difficult to attain for such things as the purchase of fertilisers, and there is danger that the raiyat may be still further involved with the money lender if the year's crops are not successful ; but, with the security of the whole village and the constant check on each individual borrower consequent on the unlimited liability of all, the repayment can be gradual, provided fixed sums of capital and interest are recovered after each harvest.

From all parts of the world we learn of the success of this system and of its educational influence, for none but reliable men are trusted with loans, and this is a great incentive to hard work, honesty and thrift.

Through a village Bank the loans need not be restricted to agriculturists only. Trades can be fostered, provision being made for the instant calling in of capital when not used for the purpose for which it was borrowed, though as was mentioned before, little ready cash need be placed in the hands of the borrower, as the banking committee purchase the necessary articles.

It may be said that those who have money are not likely to join their poorer brethren in such a scheme. But the history of village associations in India disproves this. They know well what serves their own interests, have always taken the leading part in these, and have made concessions to the poorer peasants such as we do not find in Europe, as is the case for instance in letting lands to combinations of tenants who wish to grow the *betel leaf or pan, till the concession from time immemorial has almost become a right. But even if at first the more well-to-do farmers kept aloof, they would soon find it to their interest to join such associations.* In England farmers possessed of a fair amount of capital do not find it easy to obtain seeds, feeding stuffs and manures, at as low a price as the co-operative societies can get them, and credit is often out of the question with individuals for these purchases, whilst Rural Banks can provide it on easy terms. There are few farmers in Indian villages who can be compared with the tenant farmers in England ; yet in the Eastern Counties Farmers' Co-operative Association, established at Ipswich in 1904, the 686 members have, on an average, 309 acres each, an extent of land not often tilled by farmers in this country.

As soon as the credit obtained enables the villager to increase his crop he will see that it is to his interest to ask the banking committee to help him to the best price for his produce, he learns the value of co-operation in this respect also, and avoiding the middleman, in whose bags the profits of many a bumper crop have hitherto found a resting place, gets rid of one more encumbrance for ever.

I may be allowed to suggest the foundation sketched, after a tour around the State of Junagadh, on which, it appears to me, our Raiffeisen Banks may be built, and I hope it will be possible to carry out the plan with necessary variations in other parts of India. It is merly an extract from the notes made for my Annual Report for the year 1908-09 and I shall take it as a favour if gentlemen long connected with Kathiawar and neighbouring Native

States will point out the defects and suggest improvements if they consider the scheme at all practical. Under the Chapter "Indebtedness of the farmer" I wrote:—

The raiyat is invariably in a state of indebtedness, averaging as far as I could ascertain in Junagadh territory, about Rs. 250. Much of this dates from the famine year and is due to interest upon interest, which is charged at the rate of 25 per cent. Heavy as this burden lies upon the peasant, it does not give an idea of what he actually pays on loans. His produce goes to the sowcar at a rate far below its market value and by the time he is done with one transaction, 75 % is nearer the return received by the money lender than the nominal 25%. For immediate cash the creditors would probably be satisfied with 1/3 or 1/4 the amount on their books. The payment of this, however, would be of little use in a short time, for, in the absence of funds, the farmer must again fall into debt, and, as he can pledge nothing but his produce after the State share is paid in, a heavy rate of interest must be imposed on a commodity so uncertain of realization. No doubt the power to sell or mortgage land may lead to still greater evils unless some plan be devised to check the danger. There appears to me a chance—particularly in this State—of counteracting the liability to serfdom, following sales, by the introduction, of course on a very limited scale at first, of an amplified Zampli, that should take the place of the Raiffeisen Banks in Europe. As I understand it, the Zampli is a system in vogue in every village in Junagadh and in most places in Kathiawar, by which provision is made amongst the peasants themselves to raise a common fund in order:—

1. To pay the batta charges of the havildar on

guard at the Kalawar or village granary, when the system of payment to the State in kind prevails.

2. To erect his hut in the Kalawar.

3. To give charity to fakirs travelling singly or in groups from village to village.

4. To pay for the worship of the gods.

5. To meet the expenses of deputations sent to crave a redress of the village grievances.

6. To pay any other expense common to the whole village.

For this purpose the raiyats meet to elect five or more of their number, who are authorized, in the name of the village, to borrow money from a merchant at from 10 to 12 per cent. more or less. Money is not always borrowed, but commodities are taken, as required, on credit.

When the produce is harvested the common debt is distributed among the villagers according to the number of santhis held. (A Santhi is 20 acres.) It generally varies from As. 4 to Rs. 1-4-0, more or less.

Every peasant has the right to check the accounts, though the patel and leading raiyats settle all matters connected with the fund.

Here we have the co-operative principal carried into practice for ages in India, and it appears to me that no better soil can be found for the growth of co-operative societies than that of Kathiawar affords. It may be that, in the Zampli, the amount contributed by each individual seldom reaches a figure beyond what in

Europe would be considered a trifle, but we have a foundation for co-operation such as was not to be met with in Europe when Village Banks were first established, and, if the security for the small sums controlled by the Zampli precludes all possibility of loss, the history of Co-operative Credit Societies in the West shows as few signs of bankruptcy, and so great a positive gain, that all true lovers of India should be encouraged to make an attempt fraught with such immense possibilities for the country.

The question then that meets us is whether any amplification of this institution or of similar unions in villages in different parts of India may not meet the larger wants of the agricultural population.

It may be useful, at times, to repeat the tritest sayings. Money will only be lent for money's value. Were a co-operative society to undertake the assistance of the raiyat on commercial lines, it would require the land as a security in order to offer cheap loans. To this the Junagadh State objects and there may be other rulers of a similar mind. The result is when the farmer resorts to the sowcar the latter does not take anything under 25 per cent interest for the risk he undergoes when he accepts a lien on the produce after the State share is paid. If the land could be mortgaged or sold the interest charged would probably drop to 10 or 12 per cent. A certain amount of land, however, would at once leave the raiyats hands to fall into those of the money lender. Extensive would be followed by intensive cultivation, but an undesirable state would ensue in the formation of a class of serfs, and the remedy might prove worse than the disease. Things would be otherwise were the State to act as Banker and the plan might be tried at first in one or two villages. The land should be leased for a fixed number of years, at the end of which absolute *ownership would revert to the State. This would leave a power in the hands of the Government to rectify, at fixed periods, the evils arising from the possession of land by such as are not agriculturists. At the same time it would enable even those who do not join the Co-operative* Society to borrow on better terms than at present. The price of the land would at once rise, and be a valuable asset. The debts of the raiyats could then be compounded on easy terms and the present Zampli so arranged as to become the foundation of the Village Bank. The Central Bank, which might be the State (and this would be preferable), would lend money to the village as a whole, represented by its Zampli, at, say, 4 per cent. and in order to cover working expenses, the Zampli or Village Bank would lend to individual peasants at 6 per cent. Knowing that the property of each was at stake, the villagers would take great care that only the right men would obtain loans and see that the money was properly expended. Should the rent be required before the produce is disposed of by sale, the Village Bank should have such a sum in reserve as would enable it to make the necessary loans. As the common granary already exists for providing the State share under the Bhagbatai or Share system and Vujevero or payment of the rent partly in cash and partly in kind, a common sale of all the village produce to the very best advantage ought not to be difficult to accomplish, and those accustomed to the sale of their produce in common and aware of its advantages would soon place their money in the Village Bank in order to swell the wholesale purchases and bring about a reduction of retail prices. The fall of their original debts by 60 to 70 per cent., the interest lowered from 25 to 6 per cent. the watchful eyes of their own Zampli, the new hope revived in the breasts of the despairing peasants, would soon *raise them from a state of indebtedness, and the co-operative principles thus put into practice would, ere long, render them comfortable, comparatively wealthy, and perfectly contented.*

As matters now stand in Junagadh, the State is practically doing the work of a Central Bank on a small scale, lending money for wells and bullocks to individual raiyats without interest, repaying itself the interest merely by the more intensive cultivation resulting. But the State lays down certain conditions that must be fulfilled and the peasant fears that he will be thrown back into the hands of the sowcar, and instead of one creditor have two, and he prefers to be in the hands of the sowcar who bides his time, rather than be indebted to the State, which must inexorably enforce its claim when the day of repayment comes round, as there is practically no security but the crops of the year. The demands for the return of the loans must naturally be at shorter intervals than a Village Bank with the security of all the adjacent lands would allow. If the period of repayment were extended over a larger period and arrangements made for the supply on easy terms of seed and manures, no loss need be suffered and little hardship felt, and it would result in a far larger purchase of plough cattle and the digging of a greater number of wells, without pressure from the State, and with little trouble to its officers.

To those gentlemen anxious for the progress of India, who approached the British Government on the subject of a Central Bank to aid Co-operative Societies and Village Banks, I would suggest a small trial on the lines laid down here, for I believe it would not be difficult to graft upon this Indian stock a branch of the co-operative tree that has grown so rapidly and spread so widely in the West.

FIRST LESSONS IN AGRICULTURE.

The Air.

Before seeds are placed in the soil the land is ploughed. We all know this, and the smallest little peasant boy smiles when he hears it read.

Now thoughtful men invariably ask why a thing is done. It is not for nothing so much labour is undertaken by men and cattle. There must be some end in view. We therefore ask for what purpose the ploughing takes place.

(1) The soil must be loosened to admit the seed, and to render it possible for the rootlets to find their way to their food.

(2) To prepare this food, air, warmth and moisture are wanted, and we shall see how this is brought about by the action of the air upon the ploughed land.

(3) When we break the caked surface, we not only allow air and warmth and moisture below the surface, but also allow of the upward action of water towards the surface.

(1) We know that seeds can be kept for very long periods in dry dark places and retain their vitality for thousands of years. When such seeds, after so many years, were placed in the soil and obtained warmth and moisture, they sprouted, grew well, and gave a harvest. If the seed be left on the surface and not destroyed by birds or insects, it may sprout and continue to live

while the food contained within it lasts, as we find seeds growing in gunny bags that get wet, but the little roots will be unable to force their way into the soil and the poor little plant will not be able to get much of its necessary food. The paddy is kept moist and warm in many parts of india till it sprouts, but then it must be put into the soil to get its proper food.

(2) It will be noticed that in the cold weather unpleasant smells are not so much noticed near heaps of refuse lying about, especially if the air be also dry, but that in hot, moist seasons it is very unpleasant to remain near such garbage for any length of time. We see here that heat and moisture help to decompose vegetation, as they help the seed to first decompose before sprouting.

In a similar manner the earth itself breaks up under the influence of the weather. If it is hot and dry, the earth bakes like bricks. When there is slight moisture, it softens and opens out.

It is the business of the farmer to get everything done as cheaply as possible, and if the air can work for us, and work well if we know how to use it, why not make a farm—labourer of the air? That the air contains moisture is known to you all. If you have ever seen a glass of water with ice in it you will notice that the outside gets clouded and finally drops trickle down; and people sometimes say the glass sweats. Of course the glass does not, and no water gets through it. What happens is that the air around the glass is condensed and the moisture in the air is, as it were, pressed together by the cold, and forms drops upon the glass. We find in a heated room that moisture settle, on the window panes. We can compress the air without ice and without bringing it down to the temperature of ice. A slight cooling will be sufficient to bring about a slight pressure, which will force the air to deposit a slight amount of its moisture, and if this be continued for some time it is remarkable how much moisture the air is compelled to deposit. When the dry air passes over a chatty of water it sucks up some and in the process the water cools. When damp air passes into a cooler spot it delivers some of the moisture it contains. Dig a few inches under the surface and you will find the earth cooler than at its surface. If we dig up the soil so that it is loose and somewhat fine, what will follow? Exactly what takes place in a cooled room when heated air is allowed to enter. Cool and hot air cannot remain stationary. Side by side movement will follow. The heated air will take the place of the cool air and the cool air will take the place of the heated air, till the heat is equal in both places. Some rooms in the house, where the sun seldom shines, are considerably cooler than the outside air, and, the moment a door or window is opened, the hot air rushes in and is cooled, and then succeeded *by more hot air which is again cooled, while at the same time the cold air finds its way out. Exactly the same takes place in the soil. We have but to open the* doors and windows of the soil, somewhat below the surface, and the heated air from above rushes down into the ploughed soil, is cooled, and the draught continued. The heated air bringing moisture from above is deprived in cooling of some of its moisture. To prove how much can be gained by making the air a servant on the farm, the following easy experiment should be tried. In the very hot weather select two small patches on a very dry field. Dig up one fairly deep and break the clods fairly fine. Leave the other undug. A few days afterwards, on returning to the spot, practically no change will appear to have occurred on either plot; but on removing a few inches of the surface soil, where the land had been dug, signs of moisture will be evident.

Having found that we can extract moisture from the air, can we learn anything else? The best way to ascertain facts is to make practical experiments. Plough two plots of land some time before sowing. Cover one with a loose stack of hay. You will find that the crop grown there during the year, and perhaps for two or more years afterwards, will be better than that grown on the plot left bare. As will be seen later on, when we speak of soils and how they are formed by the breaking up of rocks owing to the action of heat and moisture, the heated air has been drawn down to the soil kept cool by the hay or straw over it, and the moisture from the heated air above is, as it were, squeezed out of the air as from a sponge and deposited on the land, which then begins to break up and rot, in a way very similar to vegetation. It breaks up into the parts of which it is composed. You understand this when you look at the different soils that you meet. You have only to see the hills and rocks and stones around you, and you find, as a rule, that where these differ, the soils generally differ. These have been broken up by the weather, and the finer particles making up the soil are still further broken up, not only mechanically, i.e., into still smaller pieces, just as you would divide wood till it becomes sawdust, but also chemically, i. e., into the substances of which it is composed. Wood for instance, contains water, coal, and ashes, and by burning, these parts are separated. Water, coal, and ashes are not wood, but they are the substances of which wood is formed. They are its component parts. So also soils are made up of various substances, some containing much lime, others much iron, and most containing small portions of phosphorous, potash, etc. In some soils, where vegetation decays, you see the nitrate of potash forming a crust on the surface, and this salt contains two very useful and necessary foods for plants.

3. Besides the moisture admitted into the soil by good ploughing, we also make the air, which is within the soil, do our cooly work. It acts as a khos, or piccotah, or pump. If the end of your cotton dress dips into water, you find that water can rise considerably above its level, and if you leave the end of a piece of cloth that is hanging up to dry, dipping into a tub, or bucket, it will not dry, but become more and more wet as it draws up the water from below. This is called capillary attraction. The hairs of the head (in latin capillus—a hair) are hollow, and the spaces between the threads of which the cloth is made, form similar narrow tubes. It is peculiar that such narrow tubes draw water upwards. When the land is well tilled the earth contains numberless such hollow tubes, and where there is water below the surface it is drawn upwards through these.

This explains why the land is ploughed. The matter will be much clearer, when, later on, we come to know how, and of what, the rocks are made up, and consequently the soil derived from these rocks. We shall also learn what food is required by plants and how it is got from the soil. In the meantime let us know the reason for ploughing, and then we may more easily understand those good gentlemen who are constantly advising us to use European ploughs and to plough deep.

We may also, from what has been said, come to a knowledge of the reason why it is the custom to plough a different number of times, when different crops are to be grown. In itself it is not bad advice to tell you to plough deep. But then you must manure. When the soil is only a few inches deep it is not the best plan to send the plough below this and bring the inferior sub-soil to the surface, and if this shallow soil contain couch grass and you use an iron plough, you will ruin your field. When you have a sufficiency of manure you may plough deep in a deep soil, and nothing but good can result from it; but where manure cannot easily be had, though deep ploughing may give you a few good crops, your land will soon be exhausted.

We must not ask ourselves "How many times should the field be ploughed?" but "when does the ploughing complete the work we had in view?" The object of ploughing is to admit air, warmth, and moisture, and we must consider what time is the best to do this work, in such a way that the soil is acted upon, divided finely, and made to decompose, so that the food is prepared for the plants to take up. Experience alone will teach us this. But experience is a hard and costly taskmaster and it is advisable, where we can, to learn what others have done, so that we can avoid their mistakes and benefit by the good results they have obtained. Every farmer is naturally in no hurry to start something new, and, when he hears that his neighbour is experimenting with some such thing, he pooh-poohs it, and sneers at the man for trying to show himself wiser than his father and grandfather and the rest of the village, but still all keep round the corner to see if what he is doing will prove of benefit, and, the moment good results occur, they take care to do the same, perhaps saying, to save their faces, that they knew all about it, and that an old farmer now dead, did the same thirty years before.

There is an old saying that

"Clods upon a field
A fertilizer yield."

But then even the oldest saying must be rightly studied, or evil may result from listening to it. So much depends upon when you plough and how deep you plough as to whether clods will be advantageous or otherwise. If a shallow plough merely threw up hard sun-baked clods like bricks, little good would follow. The air between the clods would be as heated as that on the top, and no moisture would result, and consequently no decomposition of the soil, while the seed bed would be hard and unsuitable for sprouting plants. On the other hand if the surface were reduced to a fine powder, the first watering would cake it, and young sprouting plants would not be protected from either sun or rain, and would have nothing to cover their roots and support their stems, as the water contracted and lowered the surface. All this is known to the practical farmer, who is frequently told to plough his soil immediately after the harvest, and to let it lie over in this state for months together. Such advisers forget that, by the time a new crop was to be grown, the whole field would be reduced to an impalpable powder, and the first watering would render it worse than if it had never been ploughed. As we are treating here only of explanations of what the farmer does and not teaching him the business which has been handed down to him by practical farmers for some thousands of years we are not going into the *question of tillage. Each farmer can make small practical* experiments as to deep and shallow ploughing, shade crops, the ploughing of the soil immediately after a crop is romoved if another crop is likely to follow not very long after, etc. The great point to be brought to his notice is that the air can be made to cooly for him, and knowledge of this will save him much expenditure, and benefit the land greatly.

Very often the peasant is seen to put into practice what science afterwards explains to be the proper method. There are two ways, for instance, in which the soil is improved nearly everywhere in India, of which one receives the sanction of the authorities, and the other is set down as stupidity and woeful waste :—I refer to shading the field by such growth as Lucerne, and covering the surface of a ploughed field with manure for some time before working it into the soil.

Where the field is covered with thickly set leaf plants there is a greater fall of dew and a more constant exchange of hot damp air which deposits its moisture below, the land is not caked by the hot sun, and the porousness of the field allows the air to act upon the soil to break it up and decompose it, and weeds are kept in check. In order to see the effects of ploughing after the crop is mown, two fields should be compared, the one ploughed immediately after the mowing, the other left unploughed. The results of the succeeding crop would show the different effects upon the soil of the different treatment. Of course different soils are not to be treated in the same way. The longer a sandy soil is kept under shady cover, the better, whilst clayey soils want some exposure after a rough ploughing. It is *perhaps for the purpose of better aerating the soil, though the farmer may not be able to give the reason, that manure is allowed to lie on the surface instead of* being ploughed in where soils are heavy. Indian peasants are often blamed for this on account of the loss of plant food that is thus allowed to escape into the air ; but the question to be settled is whether the loss of this amount of plant food is not more than compensated for by the aeration and tilth the land receives, and we should first ascertain this by actual experiment on adjoining fields before condemning the practice that in many places is time-honoured. One of the points not yet mentioned with regard to ploughing has not been accepted by agriculturists hitherto, but the Indian raiyat will probably be more inclined to agree that it is worth studying than the majority of Western farmers and men of science. When letting the upper air into the soil we also allow the air contained within the soil to escape. This is of great importance in dealing with such weighty questions as rotation and fallowing. In practical experiments many of our readers may have noticed that the same crop cannot be grown indefinitely on the same soil. In course of time it first sickens, and, later on, a new crop will not grow. The usual explanation is that the soil is exhausted, that the crops have taken from the soil all the plant food it contains. But such a reason will scarcely do nowadays when we see that in Europe the study of Chemistry and Agriculture is brought to such a pitch, that scientists know exactly what has been taken out of the soil by a crop (how, will be explained in the Chaper on Manures), and put back as much food as the crop requires and more. Yet, after a time, the same crop will not grow unless rabing is practised. We must look for some other cause. Every farmer knows that one plant has a smell quite different from another, and that the odour of the roots is even more pronounced. The very soil can often tell you what has lately been grown in it by the smell left behind. Now plants, like animals, have their likes and dislikes. Animals like and dislike each other intensely according as the smell is agreeable or not. Some plants grow well only when they are grown together, and sicken and die in the neighbourhood of others. Some like the neighbourhood of one sort and thrive better near this than near any other, and some plants simply will not grow in the neighbourhood of others. This may some day be explained by the aid of Chemistry. We may find that some plants, like certain animals, live on the excreta of others, and that some plants sicken and die from what nourishes and fattens others. Here we may get an explnaation of the necessity of rotation, and close observance of those plants that get on best in succession to certain others must form the constant and earnest study of the progressive farmer. The peasant who uses his brains on his farm need never have an idle hour in which to worry over his lot, and become dissatisfied through envy of the people living in towns.

A great deal of attention may also be given to the question of fallow. It was very common in Europe, before Agriculture was studied as a science, to cultivate for two years and then allow the land to lie fallow for one year. Though fallowing is still carried on it is now resorted to only at much greater intervals. It is often after 4, 5, or 6 years, and, in some cases, only after 9 years that an acre is left uncultivated for one year. The object of fallowing was expressed in the peasants' words :— " The land requires rest to get new strength."

If you do not manure, your land will become exhausted in course of time, it is true: but if you leave the land unploughed it will become worse year by year. Any one who has seen a forest denuded can prove this. Whilst the land is shaded by the forest trees, the soil is good and fit for further forest growth, especially for seedlings; but when a space is cleared of trees, the soil gets baked and hardened, the air no longer enters to do its work of decomposition, and the land is fit for nothing but weeds and coarse grasses. With manuring and change of crops, little fallowing is required. With or without manure, fallowing is necessary when the same crop is grown year after year in succession. A careful attention to the aeration of the soil, to manuring, and to a proper rotation, may serve to keep under cultivation millions of acres now lying fallow every year.

Before proceeding to learn something of the composition of soils and the principal plant foods they contain, we must first learn a little more about the air and find out how it acts upon the soil.

When the wind blows we feel its movement and see the gentle flutter of the leaves, and when a storm occurs we find even big trees uprooted. Is the air an element, i. e., is it a thing that cannot be broken up into different component parts, or can we find out that it consists of a number of different things? We have seen that wood when burnt is divided into water, coal and ashes. When boys in school learn chemistry, one of the most interesting lessons shows that water is not a single substance, but is made up of two quite different things, viz., two gases, hydrogen and oxygen. As an electric current finds its way into the water the latter becomes gradually less and less, till finally it disappears, and, in the glasses or tubes, instead of water, we find two gases that once formed the water. We cannot see them for they are like the air, but we can prove that they are there. One of them on leaving the glass will burn, the other will not. In the first a match lighted and blown out but still glowing will not burn again but will go out at once; in the latter it will burn into a flame. Here we see two gases instead of water, and these two gases have different properties. The air also contains a gas, nitrogen, of which we will treat soon, and vapour, i.e. invisible steam, and carbonic acid. It is only when the water which everywhere is being drawn up in an invisible form is cooled by the air, that we notice it like the fine smoky vapour coming from a boiler, which further condenses in the air and falls in very fine rain drops, as you may have noticed if you have ever stood near a railway engine, when the driver opened the whistle valve, or let out steam at the station. This *vapour in the air is condensed, by cooling, into dew, and clouds, and rain; and of the way to cool and condense it for the fields we have spoken in the previous pages. It* so happens that the oxygen gas in the air is necessary for our breathing. In breathing we take the air into our lungs, and when we breathe it out it is no longer oxygen, but a compound called carbonic acid, which is made up of oxygen, and carbon or charcoal. Oxygen enters our system and warms us up, as any quick breathing will show; but the warmth is caused by something burning within us, and this, with the oxygen, is cast out of the system, when we breathe out. This gas is called carbonic acid. It is a gas that will not support life, and where there is much of it and no fresh air, we die. If for instance a room be sealed up by closing all the doors and windows and a seegree of charcoal be kept lighted for some time, say through the night—it causes a heaviness, followed by unconsciousness, and death. Even in a crowded room breathing becomes difficult, and persons who are not strong faint. If you burn a candle under a glass dome, it will continue to give a bright light for a short time, when the flame will get blurred and finally go out. For burning we require the oxygen gas of the air. As long as fresh air is admitted the burning continues, and the more fresh air we allow into the flame, the better it burns, because there is always a fresh addition of the oxygen gas of the air to help on the burning process. But under a closed jar the oxygen of the air is soon used up in the flame and combines with the carbon given off by the burning article to form carbonic acid gas, and, when there is no more oxygen, the flame dies out. If, now, you take some lime, and shake it up in water, and then filter it into another glass it will appear clear like any other water ; but pour this into the jar in which the candle had been burnt and which went out after a time, and you will find that there is still lime in the water and that it takes on a milky appearance owing to its combination with the carbonic acid gas in the jar. If you blow into similar lime water the same will occur, proving as we said before, that the air we breathe out is the product of oxygen and some of the carbon or charcoal within our system. It is bad for man, but it is necessary for plants, which, to build up their frames, breathe in the carbonic acid, and, under the influence of sunlight, perform a wonderful chemical action. They retain the carbon to build up their bodies, and breathe out the oxygen to give fresh air for the use of men and animals, who again breathe in pure oxygen and breathe out carbonic acid. Is it not wonderful how everything in this world can be of use! This is the food that plants get from the air. Now this has been brought in here not for the teaching of Chemistry, or to introduce a chapter on plant life, which will find its place later on in this booklet, but to point out that the carbonic acid can do a great deal in aiding plant life, and to show that the oxygen of the air easily combines with other things and helps to break them up, destroying even hard things like iron by the rust formed when the metal is exposed to the air. In the same way the oxygen of the air combines with substances of which rocks are formed, and thus breaks them up, and where pure oxygen does not affect certain stones, carbonic acid, especially in water, does the work effectively. When we learn more about the component parts of rocks and other substances, and how certain acids and salts help to reduce these to the substances of which they are made, we will understand how plants get their food from the earth. In this chapter, and for my present readers, I will not treat of these subjects, except to mention that it is as easy for the chemist to tell us what a rock is made of, as it is for the farmer to learn that wood contains water, coal, and ashes. Where we see granite rocks we know that the soil ought to contain much potash, an important plant food contained in ashes, and where only basalt rocks have formed the soil, we know that the quantity of potash in the soil is about one-fifth of that contained in the soil made up of decayed granite rocks. This is important information, and we will learn more about it, when we make a study of Geology and Chemistry, in so far as they help Agriculture and farming.

There are also quantities, in the air, of a gas called nitrogen, one of the most important of plant foods ; but so far as we know at present, it can be used directly from the air as food only by those plants which come under the class of leguminosæ, most of which have butterfly-shaped flowers like the pea and the bean, etc. But this will be more fully treated of in the Chapters on Plant Life and Manures.

The Soil.

If I were to ask you to learn something of geology, I should probably hear from one of my listeners that he was deeply interested and would attend the next day, but that, just at present, his cow was ill, and his presence was required at home. Another would want to attend to the thatch of his house and so on. But when I say we shall now consider the soil and the way in which different soils are formed, you do not get afraid of big words and great learning, and you wish to hear about it, the more so if you find it will lead to something practical.

You see some parts of the country flat, others undulating, others again with hills and mountains, and want to know how all this occurred. Some places are barren, whilst others are fruitful ; and you will perhaps be surprised to learn that this depends upon the nature of the rocks from which they were formed. We can learn how these stones were made, and how they were broken up, and consequently how the present fields you cultivate took shape, and were rendered fruitful. Geology teaches this formation of the rocks from which our soils have been built up.

The earth was once a fiery body like the sun. It was very much larger than it is now, but not so compact. Is course of time it began to cool, and the cooling was first seen on the surface. Years after the surface or crust had cooled, the interior remained very hot. You see this every day. A chapatti just off the fire may be handled without difficulty, because the outer portion cools raqidly, but when you break it, you find the inner portion is far hotter. If you take a loaf of bread that is just nice and warm outside, it may be steamy inside. It you allow your cunjee to stand for some time, the top will cool and cake over, but when you remove this caking you will probably find it far too hot to take. There are mountains at the present day, in various parts of the world, that throw up ashes, and even molten matter that runs down the sides in deep wide streams. In a few days the surface of this stuff that came out looking like molten iron, becomes cold, and appears like ordinary rock; but for years after, if you were to dig down into the mass, or an opening should be somewhere formed in it, scorching steam would ascend, enough to burn you. In the same manner, when the great molten mass forming the earth many ages ago, began to cool, the surface hardened, while the interior is still intensely hot, as may be learned from the volcanoes, and the geysers or hot springs to be found in different countries. The cooling of the surface caused a compression of the moisture-laden atmosphere over it, as explained in the last chapter, and moisture was deposited. This went on till the globe was covered deep in water. Here shell fish grew in abundance, in different parts, as we see nowadays on the sea-shore, and marine plants died and decayed; and more shells and fish followed, and more sea plants, only to add to the heap, till, in thousands of years, great depths of such accumulations existed, and the pressure of these immense masses hardened them into rock. In the meantime, the cooling of the earth in the interior was going on slowly, and the outside pressure on this crust increased. What was likely to happen soon took place. The contraction in cooling made some parts rise as the others fell, and the raised parts appeared above the water forming land and sea, and, even on the land, hills and valleys and lakes. The rain and the running water scoured the sides of these raised hills and mountains, and, when water got into the crevices, and, in turning into ice expanded, it broke off huge pieces, which were tumbled down the hill-sides and broke into smaller pieces, and these were rubbed against each other in the streams and were rounded and ground down. The larger blocks are found where these rivers begin; further down they become smaller and more rounded, and, further again, they grow smaller into pebbles, and finally into little particles of sand, which are carried off mixed with the muddy water and either deposited in the sea, or lakes, or, on the overflow of rivers in flat countries, on either side of the banks, till the water being undisturbed, they finally settle down just as mud stirred up in a glass of water, after hours of rest, gradually sinks to the bottom of the glass. Thus after many thousands of years, high mountains were worn down, lakes filled in, and, at the seaside, accumulations of earth formed fine alluvial soil, such as you will find at the mouths of rivers, which are finally divided as they enter the sea by the great amount of sand and mud they bring from the mountains far away. Thus we have different rocks formed. Some started with the first cooling of the upper crust of the earth like granite and similar rocks that are found plentifully on the Madras Railway from Wadi downwards towards Madras and the Eastern Ghauts. Others were thrown up in a molten state like the Western Ghauts. Others again were built up of shells and marine growths, and, like the other rocks, were forced upwards, as the earth cooled and contracted, forming hills and dales. These hills in turn were washed by the rain, the rocks were broken up, tumbled about by the streams, and *ground down, till the water contained fine floating particles like muddy water in a glass, which, as soon as the water lodged in a hollow, settled to the bottom, and, in course of time, filled the hollows with fine earth, such as is found in the valley of the Ganges, where, for miles upon miles, a stone big enough to knock down a mango can scarcely be found.*

If we know what the various rocks are composed of, we can easly judge of the soil, without even seeing what is a foot below the surface, though it is always better to learn from the places worn away by streams and the land dug up in sinking wells, what sort of sub-soil we have below the field we cultivate.

When the rocks begin to break up, all the parts of which they are composed do not fall to pieces at the same time. Where iron is contained in the stone the action of the oxygen of the air upon it causes rust, and we find the surface covered with a ruddy crust. If they contain lime also, this will be easily washed away by water. Only when these have been washed out will other parts of the rock fall into pieces, and this process we see in the Basalt rocks that form the Deccan trap, and we are consequently not surprised to find below the black cotton soil, a layer of Kunker and a great depth of red soil. We can also learn the quantities of potash and phosphoric acid, two important plant foods, contained in these soils, and we judge that such soils are good even before a plough has opened them out.

When along the East Coast beween the Ghats and the sea, and in many parts of Southern India, we come across usur, or kullar, or soudu soils, we ask ourselves whence the rivers come, and then we find out what rocks are decomposed, and further that these rocks must contain a great deal of soda, which, in combination with carbonic acid, or sulphuric acid, form carbonate of soda, such as you see in the South, and sulphate of soda further North. The water carries the soda out of the rocks and deposits it in lower lands. The sun dries up the water, and the soda compounds remain in the soil below. When, after years, a great accumulation of soda has taken place, if the soil is heavily watered and cannot be drained, the salts are brought to the surface by capillary attraction (explained before), and, as the water is carried off in the form of vapour, the salt encrusts the soil. When you know this, you do not wonder how the soil is hopelessly bad, or becomes so, in course of time, below many tanks or canals, but you will turn your attention to remedying the evil, and this you can do only by drainage and a study of chemistry.

You will now understand that different soils are formed from different rocks, and, having found that air, warmth, and moisture break up huge rocks, you will easily believe that the same forces will break up the smaller stones, pebbles, and gravel, that underlie your fields, and you will get the air to do the work of breaking these up mechanically and chemically (as has been explained before), and of supplying you with more soil, containing more food for your crops.

Besides the mud and sand and gravel that form the soil, a most important part of the upper surface is the *humus, or that portion that contains decayed vegetation. When small plants grew in numbers they died and decayed and others sprang up, till, in course of time,* heavy layers of decayed leaves and roots were formed. Sometimes in lakes and swampy places plants grew with their roots in the earth or water below and their leaves above, and these died, and others took their place, till the lake or hollow gradualy filled up. When, in course of time, other earth was washed over this place, and rocks accumulated, the decayed vegetation was pressed into a compact mass that formed the coal now dug up for the boilers that drive engines. In other places the rocks did not cover and press upon these filled hollows, and the soil is so made up of dead roots and leaves that it is cut into blocks like bricks, dried, and used in the house as bratties are used in India. Such land must be drained and treated with lime before it is fit for cultivation. Where the hill sides are covered with forests, the rain brings down soil by degrees into the valleys below, but where the hills have the trees cut down, the soil is washed away altogether and nothing but bare hills remain, and even the soil is carried away down the streams that exist or are thus formed.

This is no mere theoretic statement. We see it going on all over the world. In South Africa, for instance, 60 years ago, the Ongars or Brak River in Cape Colony did not exist, but, owing to the constant burning of the bush and grass of the veldt and the destruction of the vegetation which held back the rain water and allowed it to move down gradually and harmlessly, the land was scoured, and now we have a river with a channel 300 feet wide and 15 feet deep.

Another evil arising from the ruin of forests is that the water, instead of going down gradually towards the rivers and thus always keeping them flowing within their banks, rushes across the bare slopes to the river, causes an overflow after heavy rain, and in a few days, after great damage is done, leaves the river beds dry. The depth at which water is to be found is also lowered, when, instead of being stopped by the roots of the trees and finding its way gradually below the ground, the water rushes off the surface to the river and to the sea, without sinking into the land around and thus raising the water level.

Now, in forests the trees grow and die down, and nothing is taken off the soil. The plants get their food partly from the air and partly from the land. But, as in dying down they give back to the soil what they took from it, vegetation can continue for years and years, and a better soil be formed in course of time. The roots, going deep, bring food from below into the leaves and branches and trunk, and, when these wither, they add to the humus of the surface. In our fields, however, something different occurs. We sell not only the grain grown, but often the stalks, as in the case of kadbi. So much is taken off the land in this case. By degrees the food contained in the soil is exhausted ; and, as plants cannot live alone on the carbon they get from the air, crops begin to fail, and finally the land does not return even the seed put into it. So we see we must put back what the plants have taken away from the soil. If you take money, or rice, or anything else, from a box, be it ever so little at a time, that box will sooner or later be empty, unless you put something in occasionally. The land is the store house for the food of plants. If you grow crops you take so much from the store, and unless you put some plant food back into the soil, it must in course of time become so poor that it can give you nothing in return for your labour. But, before we get into the question of plant food, let us consider the various sorts of fields we have, and their value for crops, whether considered in their mechanical texture or in their chemical composition. And first we shall begin with a mechanical analysis, mentioning some of the component parts that help to feed the plants. Nowadays associations are started in many parts of India with the object of introducing the newest ideas of Western agriculture in order to obtain from the land the best return, at the least possible expense, without doing any injury to the fields. When the Department of Agriculture or the Agricultural Associations are asked questions, which farmers find difficult to answer, they generally require an idea of the land upon which the crops are grown, and, for this purpose, it is advisable to have fields classified, according as they fall under one of the five heads, viz., Sand, Gravel, Loam, Clay, Lime and Humus. Of course it is not often that you can get soils that you can strictly classify as pure sand, pure lime, etc., but as one of the five substances is more plentiful on the farm, we classify the area under that head, and others, where the mixture is decided, we place under a class combining two of the headings, such as Sandy loam.

It is good to know (1) the nature of the surface soil and (2) the sub-soil, or that which lies below the upper layer whether it be a few inches or many feet below the surface soil.

Soil is termed Sandy when it contains no clay at all or up to 10 per cent. and the rest is sand. To test it, take up some soil and dry and weigh it, then place it in a glass, pour water upon it, and shake it up well. Allow it to settle till the sand falls to the bottom, and pour off the muddy mixture into another glass and let it rest till the clay settles. Finally pour off the clean water carefully and allow the clay to dry. Weigh the sand and clay separately and you will have the proportion of one to the other. Sandy land may appear absolutely useless soil to the farmer, and so it is if no manures are used. But, in America, some of the best-paying crops are raised on almost pure sand, such as the excellent oranges they send to Europe and the excellent pine-apples canned and sold all the world over, besides the finest grades of tobacco used for cigarettes and the best cigars. Gravelly soil has larger particles of stone than sandy soil, but, though poor, it can be treated in the same way, and though it requires heavy manuring, it can be rendered useful for several crops.

Sandy Loam.—When $\frac{1}{10}$ to $\frac{4}{10}$ of the sandy soil is composed of clay it is called a Sandy Loam. It is a good open soil and easily worked.

Loam.—A Loamy soil contains 40 to 70 per cent. of clay, which is an excellent mixture of clay and sand and gives good returns for most crops.

A *Clayey Loom* contains 70 to 85 per cent clay. It is harder to work, but, as a rule, contains much potash, a most useful plant food.

Heavy Clay contains 85 to 95 per cent clay. It is very hard to work, is cold, and requires deep ploughing and good drainage to give good returns.

All these soils may contain humus, or the covering of decayed leaves and roots, that are generally found on the surface of good soil. To test for this, after drying and weighing the soil, it must be heated, and the vegetable matter will burn away, leaving the mineral matter behind. The difference in weight in the well-dried soil before it is burnt and the remaining soil after the burning, making a slight allowance for the water driven off in heating, will show the percentage of humus. Heavy cattle manuring adds considerably to the humus on all soils, and renders them moist and rich.

A very important point in recognizing the value of good soil is its ability to absorb moisture. According to Schubler,

Quartz sand	absorbs	25	per cent. of	its weight.
Lime	,,	29	,,	,,
Fine Lime Earth	,,	85	,,	,,
Clay containing 45 per cent. of sand	,,	40	,,	,,
,, 24	,,	50	,,	,,
,, 10	,,	61	,,	,,
Pure Grey Clay	,,	77	,,	,,
White Clay	,,	87	,,	,,
Humus	,,	181	,,	,,
Garden Earth	,,	89	,,	,,
Ordinary Field Earth	,,	52	,,	,,

Of course the finer the soil is, the more water will it absorb, and this explains the value of good tillage where the water is not plentiful. The more water absorbed by the soil, the more will afterwards be drawn up to the surface by means of capillary attraction, as we have explained before, provided the surface is kept loose by ploughing and harrowing, or by the action of the air when the field is protected and cooled by leafy plants. You can generally tell the value of a soil by the amount of water it can absorb.

Sandy soils soon lose their water, while heavy clays, which are composed of far finer earth, allow of a slow but constant capillary action. Stamp the sandy soil well down and you will lessen the width of the capillary tubes and lengthen the time the soil remains moist, but if you do the same to clay, you block up the very fine capillary tubes that draw the water to the surface, and prevent the upward action of the water. Sandy soil, consequently, requires less ploughing and harrowing, while much greater pains, deeper ploughing, and more constant harrowing are required to keep clay soils in good condition, and to render the harvest bountiful.

But though the alluvial soils along the banks of the Ganges and the other rivers flowing through the immense plains below the Himalayas may be sub-divided *into sandy, loamy, clayey, etc., we generally classify Indian soils under four great headings, owing to their marked unmistakable differences. They are:—(1) Alluvium, (2)* Regur, (3) the Red Soils of Madras and (4) Laterite, and these occupy the greater part of the cultivated land in India. Spreading from the Panjab right into Assam, we have the Gangetic alluvium, brought down from the mountains and deposited as fine earth in the hollow between the Himalayas and the plateau of the Deccan, along the valley of the Indus and the whole course of the River to the sea, Rajputana where it is not buried in the sands, the strip west of the Ghauts in Northern Bombay, and the Tapti and the Godaveri, Kistna, and Tanjore Districts. Scarce a stone is to be found in the soil.

The Regur or black cotton soil is familiar south of this. It has undoubtedly given harvests to Indian farmers for ages, but how much fallowing had to be resorted to in order that it might continue fruitful is a question of which we do not know much. Although its dark colour would lead one at first to believe that the soil is rich in humus, analyses show that such is not the case, and Dr. Leather is convinced that it is due to some mineral substances.

It is found in the Bombay Presidency, Berar, the *Central Provinces and Haiderabad.*

Iron exposed to the air causes the red colour which we see in the red soils of the west and south of India. They do not contain much phosphoric acid, and this should be plentifully supplied to them by means that will be mentioned in the chapter on Manures.

In different parts of the Peninsula especially in Madras, Mysore, South Eastern Bombay, the Eastern half of Hyderabad, the centre and east of the Central Provinces, and parts of Bengal, the soil has been formed by the decomposing of gneiss, a species of grantie rock. Where the land is light coloured in these places, it is generally unproductive, but the yellow clays and the reddish-brown loams are fertile.

The Laterite soils though red are to be distinguished from the other red soils, as they are composed of a little clay and much gravel of red sandstone rocks, and do not result from the breaking up of such rocks as the Basalt of the Western Ghauts. They are, as a rule, miserably poor soils, and contain scarcely more than a trace of phosphoric acid, which, as we shall see, is most important as a plant food, especially in the formation of grain, the fruit of cereal crops.

Along the Southern portions of the Eastern Ghauts we find unmistakable laterite soils, which are almost worthless for agriculture, such as the land round Chinglepet.

In Europe so much manuring has been done that we cannot well compare the analyses of such soils with the seldom manured fields of India. But we learn from the analyses that manuring is far more necessary in India if we wish to have anything like the crops obtained in Europe.

Maercker has made the following classification, *which will be more easily understood when we learn the value of the various plant foods. The chief substances that are not plentiful in soils, but are required most by* plants, are nitrogen, phosphoric acid, and potash. Maercker, a great authority in Europe on Agricultural matters, states :—

Soils are poor when in every 10,000 pounds of the surface soil (the first six inches) we find.

	Nitrogen, 5 lbs.	Phos. acid, 5 lbs.	Potash, 5 lbs.
Tolerable when the amounts of these substances range from ...	5—15	5—10	5—10
Normal ...	15—25	10—15	10—15
Good ...	25—40	15—25	15—25
Rich over ...	40—	25—	25—

Of 12 Indo-Gangetic alluvium typical soils only two come within the normal standard, 7 would be classed poor, and 3 would just come under tolerable as regards Nitrogen. Phosphoric Acid was poor in 6, tolerable in 4

and normal in 2, whilst the potash was abundantly rich in nearly all the analyses, though how much of this was in a state fit to be dissolved and taken up by the plants as food, it would be difficult to state with certainty.

The same may be said of the alluvial soils in other parts of India.

2. The Regur soils analysed by the Department of Agriculture refer only to the Madras Presidency. Though many imagine these black soils are rich in humus, this does not appear to be the case. Like most other Indian soils, even the best rank among poor soils in their contents in nitrogen. It is perhaps owing to the rapid disintegration under a hot sun that the unmanured soils produce harvests. We must also remember the frequent periods of fallow to which they are subjected, to understand how it is that they give any crops at all after so many hundreds of years of tillage and practically no manure. There is no doubt, however, that the crops can be immensely improved by manuring. If we consider the poor soils in America in which such heavy crops are raised, we see the immense benefit derived from scientific fertilizing. The potash throughout India is plentiful, and, though by no means as abundant as in alluvial soils, Indian lands are far richer in potash than those in Europe. How far, however, the potash is in a state such that the plants can make use of it, one cannot say. But even where potash appears plentiful in the soil, it is not always ready for the plants to take up, and potash salts, such as those from Stassfurt in Germany, generally show very good results, even when added to fields apparently rich in potash. The farmer knows this, for he uses ashes, whenever he can, for his fields.

According to Otto, in his work "Agricultural Chemistry," there is no plant food that shows the quality of the soil better than phosphoric acid. It is true that a great deal of phosphoric acid alone would not suffice to raise good crops, but we invariably find, as a matter of fact, that all rich soils are noted for the great amount of phosphoric acid they contain. The amount in such soils generally ranges from 1 to 2 lbs. in every 1,500 lbs. of the surface soil. As a rule, when the land contains 1 lb. in 1,000 lbs. of phosphoric acid the addition of manures containing this ingredient shows little or no result. When it contains less, manures containing phosphoric acid should be employed, if we wish to get from the land the most it can give us.

There are other soils in India, many millions of acres, scattered over the country, that are totally unproductive, because they contain excessive quantities of soda in combination, such as carbonate of soda and sulphate of soda. These are generally found in places where the rainfall is light and in hollows that cannot easily be drained. In large plains like the Punjab such tracts are frequent, and, when irrigation is introduced, the soil becomes worse, unless drainage accompanies it. The salts have for ages accumulated in the land, and as water is introduced, they are brought up as the water moves to the surface by capillary attraction. When, as vapour, the water goes into the air, the salts are left behind on the surface, and kill all seedlings. Besides good drainage, a study is required of those chemical substances which will release the soda from the other materials with which it is combined. Lime is helpful to change the clay from the soft pasty state to little grains that will allow air and water to penetrate below the surface, and sulphate of lime and potash will probably, in the case of carbonate of soda, release the carbonic acid, rendering the soda not only harmless but even useful to vegetation. A study of other chemical combinations may be as useful in the case of soils impregnated with sulphate of soda.

That even good soil becomes exhausted in course of time and refuses to return harvests that repay the expenditure is evident from the history of all newly populated countries. The virgin soil at first gave bumper crops without any manures, but, in course of time, notwithstanding careful tillage, a decided fall in the return was evidenced, till the necessity of manuring was patent, and the land recovered slowly, and in course of time gave harvests as plentiful as those obtained from land just brought under the plough. The most careful experiments, carried out over a long period, show that *the same crop grown on the same land will gradually become smaller, and that when manure is not used the returns, originally much less than the fertilized plots,* drop, till it is a question how soon they will not repay the seed and the labour.

On soils where wheat and barley were grown for over 30 years with and without manures we see the difference in results :—

	Wheat.		Barley.	
	1877—86	1899—1908	1877—86	1899—1908
Unmanured ..	17·4 bushls.	11·1 bushls.	26·9	12·6
Complete artificial Fertilizer..	32·3 ,,	23·4 ,,	40·0	33·3

But there are other points to be recommended when dealing with soils. It is not merely their mechanical texture or their chemical composition that must be taken into consideration. One of the most important agricultural studies of the last decade has been the science of bacteriology. The earth is full of life so small that we cannot see its forms with the naked eye. In a handful of earth there are millions of plants, less than the nine-thousandth part of an inch in size, called bacteria. These grow and divide into two, and then grow and increase by dividing, till in 24 hours, some millions may be generated, unless kept down or destroyed by another species. Many are exceedingly useful to our crops. But I point this out not to treat of this subject in this little book, but to draw the attention of those who wish to learn more of this particular branch of study. They will find it deeply interesting and practical, for, amongst other things, it will explain to them why it is unnecessary to use certain manures for such plants as bear butterfly shaped flowers. They will then see that bacteria draw down the nitrogen from the air to feed themselves and the plants in whose rootlets they build nodules for their residence. It will also help in explaining why cattle manure can be preserved or destroyed by a knowledge of the action of these minute organisms, and perhaps aid in keeping houses and their surroundings pure and healthful, and ward off diseases so common in the country.

The Plant.

Plants are living things. They feed, grow, multiply and die. Special parts of the plant carry on different sorts of work, and the particular part that does such work is called an organ, and the work done by an organ is called its function. To understand only a little of what goes on during the growth of a plant requires a very great knowledge of Chemistry. But we can learn a certain amount without studying this science; at least enough to help us in the practical work of the fields.

As we learnt before, seeds will not grow without heat and moisture; but when they obtain this they germinate or start growing. Now examine the seed a little more closely. It contains within it, or at the side, a little speck which is the portion that contains life and will develope under the right conditions of heat and moisture. The rest of the seed has no life. It contains the food for the young plant and the covering to protect it. When the seed sprouts, we find it grows in two directions, the plumule forces its way into the air, for it contains the budding leaves, which want the light and will get a great part of their nourishment from the air, and the radicle which grows downwards as the root, covered with fine hair-like rootlets, which seek the rest of the necessary plant food from the soil.

Now we shall examine the leaf to see how this carries on its functions, and shall study the root and the work it does below the ground.

Look at the inside of an orange and you will see that the pulp is contained in fine skins; press the outer skin or rind of an orange and from the little holes or glands you can squeeze out an oil that smarts the eye when it is squirted into it by a mischievous child. Now take a microscope (an instrument that makes things look a great many times larger than they are) and you will find that these glands lie amongst cells. In the orange pulp we find the cells countain a juice, sweet when the fruit is ripe, sour and bitter when it is unripe. Leaves contain similar cells with openings like the pores of the skin between these cells. These are found principally on the lower side of the leaves, and it is from them that the water taken up by the plants finds its way back to the air as vapour. This process is called transpiration. A small leaf will contain about 100,000 such pores or stomata, and so a very large quantity of water is transpired through the leaves, though ever so little escapes from each pore. The whole plant is made up of cells which consist of a thin sack which is dead matter, and the cell contents within the sack. The chief of these is protoplasm. We saw that in the seed there was a living portion which grew under favourable conditions, and the dead food which enabled this living portion to grow. In the cells we have something similar, a nucleus or centre of life and the sap or food taken up by the plant to feed that living nucleus. But how can these cells be fed if each cell is, as it were, contained in its own separate bag, and the plant is made up of such ? How do they grow, how increase, and whence do they get their food ? Bear in mind that plants live on liquid food. It must be given to them in the form of water, though the water is not pure but mixed with various substances that help to support life. How life is generated no human being can tell. All we know is that from one life another comes. We can, by Chemistry, learn what forms protoplasm that contains the seed of life, but that does not help us much. We learn for instance, that it is composed of hydrogen and oxygen, which are the gases that form water, carbon or charcoal and nitrogen, and sulphur. But with all these at our disposal no life can be made from dead things. Now, to support this life of plants, food is required, and part, as we have seen before, is obtained from the carbonic acid in the air, and part from what is obtained from the soil. To understand how the water containing ingredients mixed up with it in the soil finds its way from cell to cell in the roots, and right up the stem to the leaves, flowers, and fruits, we must make a little experiment, which will render clear the action which takes place and is called the Law of Osmosis or Diosmosis. When treating of the air we saw that air heated at different temperatures cannot exist quietly side by side, but movement results of the cold to the heated air and of the heated air to the cold air, till both are of the same temperature. In the same manner if similar fluids are separated by a thin material like a bladder, movement begins and the one fluid passes into the second and the second into the first, and the movement continues till on both sides of the dividing material the fluids are balanced. This is exactly what occurs with the root cells forming the plant. The water containing various salts, that help to support plant life, is thus carried up from cell to cell, and finally when it has deposited the salts along its route is transpired from pores or stomata, in the under part of the leaves. A most extraordinary occurrence, and one that no science can yet explain, is the wonderful power plants have of selecting the salts and rejecting others, as we see from the colours and smell of plants and flowers growing in the same soil, and the resulting fruit, such as the various crops grown on the farmer's land. How these salts are combined and changed we do not know. The greatest chemist's laboratory does not show anything like the remarkable work going on within the plant during its lifetime. A part of this water, laden with salts, carries food into the interior of a cell and so it goes from cell to cell with wonderful rapidity; and part also is carried along the outer cell walls and finally is transpired through the leaves, after all the nourishment has been drawn from it by the plants.

Nobody yet understands all the wonder of plant life. You will naturally ask if the cells become bigger and bigger and thus make the tree grow. Such is not the case, or you would have all the plants and trees with great hollows in them.

After a time, as the protoplasm or living part within the cell, grows, it divides, a new lining is formed between the two particles of protoplasm, and thus there are two cells where there was one before. This splitting and increasing in the number of cells goes on at a very great rate, and, as the old cell walls harden, many of them die as new ones are formed, and we have the solid interior wood of the tree. Remember that all the cells are so small that it wants a microscope to see them. It would be very interesting to all farmers if there were a microscope in each village school, and the children had the opportunity of learning how to use it. Little harmless looking specks would then be seen as what they are, viz. quickly increasing communities of animal life eating away the very essence of the plants on which they live, or vegetable life exhausting all the sap of the plant on which they grow.

We have seen that there are openings between the cells of the leaves, which serve, like the pores of our skin, to help transpiration. Can we prove this? Yes, very simply. Take a leaf and place the lower side on a piece of tin, and, after a few seconds, remove it, and you will see that the vapour escaping from the leaf has been condensed by the cool tin, and appears where the leaf lay, as little drops of water. Turn the other side of the leaf on the tin. There are few or no stomata there and consequently we do not expect to find any water; but a little will be seen by the escape of some vapour through the thin covering of the cells on the upper portion of the leaf. Thus the food taken up in the liquid state is retained in the plant and the water transpired. But, besides breathing out water vapour, plants take carbon from the air to build the coal we find when the plants are burnt. Though air containing much carbonic acid is injurious to animals, it is food for plants, and, as we said before, plants take in the carbonic acid, and, in the sunlight, decompose it, assimilating the carbon and breathing out the oxygen. This can be proved if you breath into a glass, turn it upside down in water, and place a plant in the glass. In the sunlight, in course of time, though no change seems to take place, the breathed air containing carbonic acid will not be there, but only pure oxygen will remain, for a lighted match introduced will burn brightly although if put into the bottle before the experiment it will go out at once. If not kept in the sunlight no change would take place in the air within the bottle.

Besides water and carbon from the air, we have seen that the plant takes up various substances from the soil, such as zinc, which, with water and air it contains, forms in combination with iron the green colouring of the leaf, carbonic acid, nitrogen, sulphur, lime, phosphorous, potash and a great number of other metals. Of these substances most soils have an abundance for plant life, but the chief needs of the plant, as we shall learn in the next chapter, are nitrogen, phosphoric acid, potash and lime, and these are seldom present in sufficient quantities in the fields where crops have been grown for a long time.

You know from experience that as wood dries it loses its weight. A great part of it is water. When wood is burnt smoke arises, and coal and ashes are left. The smoke is the partly burnt wood escaping into the air, the coal is the carbon, and the ashes contain that portion of the plant which has been obtained by the mineral or earthy portion of the soil. Men of science can, by means of Chemistry, analyse the ashes, and find out how much lime, phosphoric acid, potash, etc., is contained in them, and thus tell us what is taken out of the land by the crop. These substances are again produced by the breaking up of the soil into its component parts through heat and moisture, but this process is slow, and we find ourselves forced to put in these substances as manures if we wish the land to continue to be fruitful and to give abundant crops. The same analyses can be made of the manures and fertilizers used, so that, when we know what the crop takes from the soil, we can use fertilizers, and grow crops on even the poorest sandy soils, such as the orange, pine-apple and tobacco soils of America, that by such means are made to pay much better than excellent soils in India, which are not so carefully and scientifically treated.

Manures.

The food useful and necessary for plants must be placed at their disposal if there is not a sufficiency in the soil. This is called manuring or fertilizing.

In the jungles plants grow and die and go back into the soil from which they rose, and nothing is lost; consequently no manuring is required. In course of time the roots go deeper and deeper into the subsoil and take up the food into the roots, stem, branches and leaves, and when the leaves decay and fall they add to the fruitfulness of the upper surface, making a rich, porous humus, containing all the young plants require. And so, as time goes on, the soil is improved, and the young trees of the jungles grow better still.

But this is not the case in our fields. We take away the corn and probably sell it, and even much of the stalks is disposed of away from the farm. By degrees, therefore, it may be very slowly at first, the land begins to show signs of poverty. Virgin soil is generally rich and gives large crops, such as the lands populated in comparatively recent times in Canada, Australia, and the more Western of the United States. But even in such countries it has been discovered that farming scarcely pays unless manure is used, for the land has had so much of the plant food taken away by the crops, that the farmer must add it, if he wants a good harvest.

What do plants require as food? The first thing that will enter your mind is 'cattle dung' and 'farm refuse.' It is true that these are excellent fertilizers; but can we get enough of them anywhere? If in Europe, where the animals are stall fed and carefully looked after, there is not enough for the fields, can we expect a sufficiency in India? Only the garden crops, or those that can be watered from a well or canal, are treated with farm yard manure, as a rule.

Now what is it that plants require for their food and how much of it is to be found in cattle dung or farm-yard manure, that acts as food for plants?

It is extraordinary how many things are required to build up the body of a single plant. Any number of metals are taken up in the form of salts dissolved in water. Most of these, however, are to be found in sufficient quantities in nearly all soils.

There are four principal ingredients of plant food that are not in sufficient quantities in the majority of soils, viz., Nitrogen, Phosphoric Acid, Potash, and Lime.

Nitrogen is known by its pungent smell, when, as ammonia it is noticed from urinals or where much cattle dung and urine are heaped together. It will also be noticed if clean dry bones are wetted and kept in an unventilated room.

Phosphorous is known to most peasants from the use of safety matches. The stick is dipped in phosphorous, and, as this easily takes fire when exposed to the air, it is coated with material to keep out the air. When rubbed on a match box, this outer covering is scratched away, and the phosphorous exposed to the air ignites and burns the wood.

Potash is found in small quantities in the ashes of plants.

Lime is too well known to require further mention, except that it is little used in the fields in India as it is seldom wanting in our soils, though it will always serve a useful purpose if applied to land containing a great deal of decayed vegetation often covered with water. In such cases the soil is sour and lime is necessary as well as drainage.

A chemist can find that water is made up of two gases in different proportions, 2 of hydrogen and 1 of oxygen. When he has found out the amount of charcoal and water in wood, he then examines the ashes and learns what they contain. In the same way he can take up a given portion of a field crop and find out what the grain and the straw are made up of, and thus see what the crop has taken from the air and from the earth.

Numberless analyses are made of cattle dung and farmyard manure. Animals, like oxen and sheep live on the grass and hay they can get, and form from it their bones and flesh, hair, hoofs and horns, and we naturally find in these the same substances taken from the plants, only the parts of which they are composed are mixed in different proportions. When animals feed on grass and hay, part of what they eat is voided in the shape of dung and urine. The dung is the food that is not digested, whilst the urine forms part of the digested matter that is no longer wanted, and is voided. We are therefore not much surprised to find that the urine contains a deal more of nourishing plant food than dung. We also know from experience that it decomposes much more rapidly, and consequently is of great importance for quickly growing crops, and helps to feed the slower growing plants, whilst the dung and litter are falling back into their component parts.

It is not the quantity of material placed upon a field that tells us the amount of plant food given to the crops. Working animals get, besides their allowance of grass and hay, a certain amount of what is called 'concentrated food', such as oilcakes. These contain *more nourishing matter in a few pounds than we find in large quantities of hay. The animal benefits very* much from such feeding, and the farmer also benefits, not merely by having stronger animals from which he can get more work, but also from the dung and urine voided. By good feeding nothing is lost. The animals become stronger and give the farmer more and better work, and the dung and urine voided are richer in plant food, and thus give a better return in the harvest.

Now let us see what substances are contained in the dung and urine of cattle so that we may learn the value of these for our fields. We can compare fresh dung with well-rotted dung, dung and urine combined, and dung, urine and litter well preserved, with badly cared for farmyard manure. We can then see what we are putting into the soil when a certain number of cart loads of farmyard manure is ploughed into the fields We can also see if other manures can take the place of farmyard manure, and whether it is beneficial at times to add other fertilizers to the manure prepared on the farm. Some manures decompose so rapidly that, when the crop, is reaped, no food remains in the soil. It has either been taken up by the crop, or lost in the drainage. Such manures are excellent when we require a rapid leaf growth; others are more necessary for the fruit, such as the grain in cereal crops, and the sugar in cane, and help early ripening; whilst others, again, help to build up the body of the plants and serve to carry the first and second through the plant. You must not think that plants live on nitrogen, or phosphoric acid, or potash alone. Each of these would no more be food for plants than lime, or sand, or water alone would form mortar, or the various ingredients separated, would form a curry. They must be mixed *in varying proportions to suit different plants. How this is done by the plant, what power it has of selecting* according to its wants, and how it varies this power of selection in different soils are mysteries even to the most learned. It can, however, make bad mixtures when in the wrong soil, taking one mineral that is more plentiful and more easily dissolved, in place of another. It is on this account you find sugarcane grown on very salty land a regular purgative. It is the business of the farmer to place at the disposal of the plant the various foods it requires, just as it is the work of the woman of the house to get a supply of the curry stuffs, which, though the ingredients may be the same, are mixed in different ways to suit different tastes. The plant does not live on single food ingredients but on a nourishment composed of different foodstuffs combined, and every single constituent part of this nourishment is effective only in the completed whole. One thing must be carefully remembered in manuring and that is termed the Law of Minima. If you had plenty of nitrogen, but no phosphoric acid or potash, placed in carefully treated sand, in glass jars used for experiments, no plant would grow. If to the nitrogen you added plenty of phosphoric acid, plants would still refuse to grow. If then you added a sufficiency of potash, but lime were not present, again no harvest would result, and so on with sulphur, iron zinc, and the numerous other minerals required by plants.

Now most soils have the majority of these substances in abundance, for plants require very little of them, but nitrogen, phosphoric acid and potash are found wanting as a rule in soils long cultivated.

Cattle dung contains everything requisite for plant life, for the cattle have got all this from the plants on which they feed. This is called a complete manure, i.e. it contains all the necessary ingredients to form plant food. There are other manures excellent for the particular purpose for which they may be used, which contain one, or perhaps more but not all of these ingredients, and these are called incomplete manures. To use such on soil that is wanting in the remaining plant food or foods would be a waste of money and produce little good. It is true there are few soils completely wanting in any of these foods, but there are many in which the quantity is not sufficient to produce a good crop. To explain how this occurs, the following illustration may be found useful. Suppose an acre contained 20 lbs. of nitrogen, 20 lbs. of phosphoric acid and 25 lbs. of potash, a sufficiency of lime and all the other substances that are required by plants in very small quantities, in a state easily soluble in water. If a full rice harvest contained 41 lbs. of nitrogen, 26 lbs. of phosphoric acid and 68 lbs. of potash, your crop would be a six anna one. If you added any amount of nitrogen, you would not get more than a six *anna* crop, for the potash in the soil is equal to about $\frac{3}{8}$ of what a full crop requires. As soon as 23 lbs. more of potash is added a sixteen anna crop will not be obtained. Six lbs. of phosphoric acid are wanting, and, till you place this at the disposal of the plants, a full crop will not be got. But if the soil contained 41 lbs. of nitrogen 68 lbs. of potash and only 5 lbs. of phosphoric acid you would not get more than a four *anna* crop, unless the other 15 lbs. of phosphoric acid required were placed at the disposal of the plants.

This having been impressed on your mind the question of the value of manures, complete and incomplete, may now be discussed.

To the careful farmer one lot of cattle manure is not the same as another. He knows that if the refuse of the farm is thrown into the manure pit with the dung and urine of the cattle, and this is well covered over, he gets after some months a well rotted, friable heap, which gives good results when ploughed into the soil, especially if the pit is so made that the liquid does not sink into the soil. If the *heap* is uncared for and exposed to sun and rain, the useful parts of the manure are washed away to make a filthy rivulet around the house, and stuff that is little better than straw, and poor straw at that, is carted to the fields. No wonder the resulting harvests are poor. It costs as much to have bad manure as good. We must therefore study how to get good manure. It is *not* the quantity we *have that tells; it is the quality.* Now to study the *quality we must learn what it contains in the shape of* plant foods, and, funny though it may appear to many farmers, we *must* learn *to regulate this quality.*

The excreta of animals have often been analysed. The nitrogen is as follow :—

In 1000 lbs.	...	*Dung*	*Urine.*
Sheep	...	7 lbs.	14 lbs.
Horse	...	5 ,,	12 ,,
Cow	...	3 ,,	8 ,,

We see here that the urine contains much more nitrogen in every 1000 lbs. than the dung, and this shows us how much money is lost when we allow this valuable manure to pour away around the home and cause nothing but a stench and bad health. It should be poured on to the heap and will serve a very important purpose as a manure, and further help to preserve the plant foods in the heap. In other works you will find more about the preparation of good farm yard manure with reasons given why it should be cared for. In a little book of 100 pages called the Value of Manures, all this is written of in more detail. You can also increase the amount of plant foods in the dung by the use of oil cakes and other materials that contain much plant food. Nothing is lost by feeding cattle well. First you can get more work out of your bullocks, and more milk and butter from your cows, and better and stronger calves, and nothing is lost. What does not go to make flesh, and blood, and bone, is voided by the animal, and that contains more plant foods. Thirteen samples of dung were analyzed by Dr. Leather. Six samples contained 54 lbs. of nitrogen in 10,000 lbs. of Excreta ; but these animals had concentrated food (oilcake) given to them in addition to the ordinary rations of hay or straw. Seven samples showed only 17 lbs. nitrogen in 10,000 lbs. Excreta, but these were village cattle that had to get their living as best they could by grazing.

Well-rotted stable dung should contain in every 10,000 lbs. of Excreta :

	Nitrogen.	Phos. acid.	Potash.
	58	80	50
Fresh human Excreta (solid and liquid) ...	85	26	21
Human Excreta removed from pits ...	37	16	15
Blood meal ...	1180	120	70
Groundnut cake ...	760	150	150
Castor cake ...	500	120	100
Sunflower cake ..	590	210	100
Gingelly cake ...	591	140	320
Safflower cake ...	580	190	
Niger seed ...	450	240	100
Cocoanut cake ...	370	200	130
Cotton seed cake ...	250	120	240
Karanj cake ...	350	160	190
Mhoura ...	260	90	80
Tobacco stems ...	300	86	600

All these and many others are complete manures. But a complete manure is not always well balanced.

Take, for instance, blood meal. If this were used for a rice crop the potash it contains would be a little more than sufficient for a 17 anna crop but there would be nearly 100 lbs. of phosphoric acid over and above the wants of the crop, and nearly 800 lbs. of nitrogen would be practically thrown away into the drains.

Many plants require no nitrogen in the soil for they take it direct from the air. These are the leguminosae that we spoke of before, among which you find, peas, beans, etc.

If they have enough phosphoric acid and potash, they require no nitrogen in the soil, for they gather it from the air. How this is done you may learn from other books later on. To use your cattle manure for these is not wise, for you are practically throwing away all the nitrogen it contains. Much cattle manure may even do harm. But plenty of ashes, and bone or basic slag, will always be useful with this crop. These who on account of religious scruples do not care to use bone will find a good substitute in basic slag. In preparing steel from iron, the one thing not wanted is phosphorous. Lime is used in the preparation, and the phosphoric acid of the iron is united chemically with the lime and excellent steel results. The great lumps of slag that were formerly carted away as rubbish, are now ground down into a fine powder, and serve as an excellent phoshpatic manure. There are some manures that contain neither nitrogen nor phosphoric acid, but are rich in potash. These are the salts dug out of the earth in Germany. Sulphate of potash contains 50 lbs. of pure potash in every 100 lbs. of the fertilizer, but has no common salt mixed with it. Muriate is as rich in potash but has also a certain amount of ordinary salt mixed with it. Kainit contains about 13 lbs. of potash in every 100 lbs. of the fertilizer and has also about 30 lbs. of common salt, which makes it very useful where common salt is required, especially for coconut palms.

It will be noticed that some contain much nitrogen and not much phosphoric acid or potash, while others with less nitrogen contain more phosphoric acid or more potash. We must therefore mix manures in such a manner that there is no waste of one of the plant foods in order to supply a sufficiency of some other. And this we can learn only when we study what the crops take from the soil. An application to the nearest agricultural association will obtain you this information.

Some plants, like most of the cereals, often require a slight application of nitrogen to give them a good start or to assist them in a soil that is naturally poor. In such cases nitrate of soda is very useful for it contains 1550 lbs. of nitrogen in 10000 lbs. of the manure. It must be used as a top dressing only, because it is not retained long by the earth, and what is not used by the plant is carried away in the drainage. Another very rich manure, very useful in garden crops, such as sugarcane, is sulphate of ammonia, which contains 2050 lbs. of nitrogen in 10000 lbs. of the fertilizer. It must be harrowed in. It is not carried away quite so soon by the drainage water, but what is not taken up by the crop at the end of the year is carried out of reach of the next crop.

Nirate of potash or saltpetre is another excellent nitrogenous manure which contains in every 10,000 lbs.

of fertilizer 1350 lbs. of nitrogen and 4400 lbs. of potash. As a top-dressing for rice it has proved excellent in various parts of India, and it will also serve for crops whose roots keep near the surface. Of course the law of minima must be remembered and a sufficiency of phoshoric acid must be added to the manure if a bumper harvest is expected. Some manures contain nitrogen and phoshoric acid, like bone, peru guano and fish, and others phoshporic acid alone, such as basic slag, bone superphosphate and coprolites.

It must be the study of the farmer to supply all the foods the crop requires. He must apply to Agricultural Societies or to the Department of Agriculture to ascertain what plant foods are removed from the acre by his various crops, and endeavour to put back into his fields at least the amounts withdrawn. But this requires some learning. It will not do to continue as the old people did. They became good farmers in time without the aid of books, but they made many mistakes and paid dearly for their experience. Now that competition is felt even amongst farmers, and other lands are growing the harvests that India alone boasted of formerly, the man who tills the soil must not only use his brains, but he must try all he can to use the brains of others. He must see why, for instance, in India the harvest is less than 12 bushels of wheat, whilst in England it is nearer 33 on an average, why 68 lbs. of cotton are obtained in India against 190 in America and 350 in Egypt. He must see what they do to improve their land and follow their example. But, above all, he must look upon his farming as the bania does on his shop. Does it pay? and how far?—are questions he can answer by well-kept books.

It is not uncommon in India to see a poor illiterate raiyat start a sugarcane patch with borrowed money, induced thereto by the splendid returns of which he hears, only to find, at the end of 12 or 15 months, to his great surprise, he is unable to repay capital and interest. He has kept no books. The cost of ploughing, manures, seed and labour have not been calculated, nor the amount of interest to be met, the expenditure on cattle, implements, water, etc., have not been entered in any books. How was it possible for him to arrive at the cost of his crop and compare that with the value of the harvest. No Farm Labour Account can be shown, no Stock Book, no Cash Book. He cannot read or write and cannot therefore draw up a Balance sheet to know how he stands.

Every year shows more plainly the necessity for education if the farmer is to succeed. The argument that the illiterate man often succeeds is a poor one, for had he the elements of scientific agricultural knowledge he could have succeeded far better, with fewer costly blunders. Nowadays the raiyat must learn what his crops cost him, the cheapest and best way of feeding his cattle and procuring his manure, the best market for his produce, and above all, the way of obtaining bumper crops at the lowest expense without harming the land. Instead of being a drudgery, his work becomes most interesting, and, instead of envying the lot of townspeople, he loves his free open-air work, puts his whole mind to it, rises in his own estiamtion and the estimation of his neighbours, and finds himself before long if not a rich man, certainly in comfortable circumstances.

A big book is not useful to the peasant. He wants a small book that he can read for a few minutes after his day's work. But reading alone is not of much use. The man who learns out of a book how he has to ride cuts a sorry figure when he mounts a horse. It is good to learn things from a book if you endeavour to put them into practice.

Now the chief things we are to try, after reading this, is the improvement of the land by tillage and manures, and a careful study of the best rotation, so that, as true farmers, we obtain from the soil the greatest possible return without harming the soil, at the least possible expense.

All experiments must therefore be carried out on small patches of land of equal size and texture and value, and every trial must have a duplicate plot to allow for differences in the soil. Only one thing must be changed at a time on the trial plots if we wish to learn anything.

It is to be hoped these few words will lead thoughtful farmers to study everything connected with the soil. As long as you are satisfied there will be no progress. You must try how you can better your prospects in every way, and perhaps this little book will put you on the way to think and act in such a manner that you will have two blades of grass and two ears of corn where only one grew before. If you do this you will benefit not only yourselves but also your neighbours and your mother-country.

THE VALUE OF MANURES.

There is absolutely no question as to the necessity of manuring. The most ignorant peasant knows that he must put something into the soil to keep the land fertile, though he may not exactly comprehend how that something will chemically decompose and give up the constituents as food for plant-life. Nitrogen, Phosphoric Acid and Potash are a jargon the Indian cultivator leaves to students of the stranger's books ; but he knows what plants are useful for green manuring, of cattle excreta he chooses the best available, often using it in the cheapest possible manner by placing sheep on his land for a night or successive nights, for potash he manages with a little burning of rubbish, and for phosphoric acid a sheep's head is often placed at the roots of sickening orange trees.

The great pity of it is that he treats his land as he treats his animals. He knocks as much work out of both as they can well stand, and feeds them as little as he dare. As long as he merely rents the land this continues—a custom noticed not only here in India, but complained of in Natal, where patches cultivated by Indians, are rendered in a few years almost barren.

Liebig (and every agricultural chemist with him) shows that plants take certain food from the soil. Now you cannot go on taking substances from the field without impoverishing it. True the land itself contains materials which, in disintegration by the action of damp and heat, prepare the mineral food the plant requires, and this goes on much more rapidly in warm than in cool climates.

Forthis very reason the depletion of Indian fields is accelerated, and the time must come when the soil can stand the robbery no longer and confesses its poverty by its inability to produce fruits any more. It is by slow degrees, as a rule, that this point is reached ; but we see the various stages all over the country. It is first disease amongst staple crops and later on complete failure, till rest to the soil by a change of crop or a time fore lying fallow, allows of another attack on its slightly recouped resources. These difficulties do not come to light in savage or sparsely peopled lands, for the inhabitants merely move on when the soil shows decided signs of deterioration. But the India of to-day will not allow of a step to the next plot, when the land has been taxed to the limit it can bear. Land is dearer, the population more dense, and the simple expedient of walking away from impoverished fields is absolutely impossible. The depleted land must be fed and restored. In other words we must put into the soil what the crops have taken from it. To do this, we must learn what and how much has been removed, and put back at least an equal quantity of food stuffs—the wise farmer will put more. A sensible landlord knows he must look after his cattle well if he wants work from them, and that health and strength mean feeding and care. *It is the same with his land. He works* it and deprives it of certain substances requisite to build up the body of his plants and fruits, and if he wants any more from the soil he must put into it what the plants have taken out. Of course this does not mean that there are merely chemical considerations in dealing with land. We know a certain amount of substance is required to feed the human body, and though the fattening and strengthening nourishment from a whole ox were put into a tea cup, it does not follow that a man could live long on the decoction. There are considerations of the physical nature of the soil, moisture, heat, and a number of others as yet little understood by the greatest scientists. Into these we need not enter. Each farmer knows his own soil pretty fairly. Few farmers, however, know the amount of various food stuffs the different crops extract from the soil. When this has been ascertained he can save his land from being exhausted or worked out.

What is a manure? Not many years ago an English farmer would have answered :—"Muck," and the German peasant would have defined it in the words :—"Was duengt stinkt" i.e. "What manures stinks." Perhaps the simplest answer is the correct one, viz., Plant Food.

Muck or stable manure and the refuse of the farm has always been the chief fertilizing material, and, no doubt, in decomposing, it produces an unpleasant smell. Even if, in these days, we had a sufficiency of cattle dung, we should still require a further study as to the best means of preserving the plant food contained in it, its value as a manure, the effects it has on the texture of the soil, and whether it is useful with every crop or wasteful (and this may sound extraordinary) with others, if the addition of certain other natural and artificial fertilizers might not be productive of increased harvests, and whether these might not, in the absence of a sufficiency of farm-yard manure, take its place, without loss to the farmer and possibly to his great gain.

The earth contains all the elements of plant food, and in forests and on grass lands where plants grow and die down and nothing is carried off the soil the land requires no replenishing, but where the produce is taken from the farm, year after year, something must be put back or the land will suffer. The plant-food resources, it stands to reason, cannot be constantly withdrawn and yet the land be expected to remain as rich as ever.

In the old days people believed that air, water, fire and earth were elements, that is they were not composed of different materials; but, since the science of chemistry has been studied, we know that water consists of two gases, hydrogen and oxygen, into which we can decompose it, that fire is due to the combination of oxygen with the material set on fire, that a number of gases form the air we breathe, and that the earth is made up of a number of materials such as nitrogen, phosphoric acid, potash, lime, magnesium, common salt, iron, etc.

As the various rocks are broken up by the action of water, cold and heat, and crumble to pieces, they are washed over the plains, and make the soil upon which various forms of plant life grow. These die down and others take their place, till, in course of time, the dead vegetation forms the humus, which serves as the best soil upon which to grow the most paying crops. Soils are different in appearance and in value according to their formation from various rocks which contain more or less of the necessary food of plants.

Although a solution of smelling salts with an infinitesimal proportion of some other saline matters contains all the elementary bodies which enter into the composition of protoplasm (the material of formation of living bodies), a hogshead of that fluid would not keep a hungry man or animal from starving, but multitudes of plants could live on it and thrive. In the same way if plants were supplied with pure carbon, hydrogen, oxygen, nitrogen, phosporous, sulphur, etc., they would not live. All these must be supplied to them in the shape of liquid salts such as nitrates, phosphates, carbonates and other compounds.

There are certain foods absolutely necessary to enable the plant to live and develope, but the majority of the constituents are found in abundance in every soil. Those that are most needed and generally wanting on cultivated lands are nitrogen, phosphoric acid; potash and lime.

But before using the few chemical terms that are absolutely necessary in studying the value of manures it is advisable to give a general idea of what they mean. If clean dry bones are wetted and kept in a closed room there is a powerful pungent odour, similar to that of smelling salts, and in the dung and urine of animals the same is recognised. It is a combination of the gases Nitrogen and Hydrogen, called Ammonia. When the bones decompose they leave in the soil lime and phosphoric acid also. Phosphorous is probably known to the majority of farmers who have used safety matches. Wood and other materials that are burnt leave ashes which contain a good deal of potash. On the farm one sees how water and heat decompose materials lying in the soil. These readily break up into the things of which they are composed. For instance vegetation that rots, gives back the nitrogen, carbon (or woody portion), water, etc., they have taken from the earth, and the air and dead animals which obtained the food by eating plants such as grass, lucerne, oilcakes, etc., in decaying, give back to the soil what they took from it in the shape of plant-food. This is one of the reasons why even grass should be manured so that the oxen feeding on it should get richer food from which to build up their bodies and even their very bones.

What is done slowly by nature can be done much quicker by chemistry. Hence we can select a portion of a field and ascertain the number and quantity of the component parts that make up the vegetation, and thus learn how much is taken from the acre by any given crop. We can similarly analyse any given manure, such as oilcakes, fish, bone, etc., and learn what they contain, if all the necessary plant-foods are present to supply what the crop has taken from the soil, or whether others should be added, and in what quantity.

The science of farming is to get from the land the best possible succession of crops at the lowest possible expense, without lessening the fertility of the soil, and the science of manuring is to put back into the earth, as much, at least, of the plant-food as is extracted by the crop, in a state that will allow the plant to benefit most by it. Of course the expenditure should be regulated so as to obtain the greatest profit. It does not follow that manuring can be reduced to a rule of thumb or become a matter of simple proportion. As in our food the absence of so small an item as a pinch of salt may render the whole unpleasant and even deleterious to health, so, in fertilizing, there are a number of considerations to be taken into account, and these will be learnt by study and experience. In order to have the best return it is not sufficient to give back to the soil only the quantity of food taken up by the plants. Much of the manure is washed away by the drainage and some foods are required in far greater quantities than analyses of the crops can possibly explain.

Manures form the component parts of the food necessary for plants. At the same time they act upon the soil in a threefold manner.

1. Chemical combinations take place with the substances in the soil. Thus, when Sulphate of Ammonia is used, it meets with the carbonate of the earth, splits up into Sulphuric Acid and Ammonia, the former combining with the carbonate to form Calcium Sulphate, the latter also uniting with carbonate as Carbonate of Ammonia. When the Carbonate of Ammonia is dissolved by the bacteria into nitrates, the carbonate and the sulphate of lime are washed out in the drainage. Hence the constant use of Sulphate of Ammonia has resulted in the loss of 3/4 cwt. Calcium Carbonate, for every cwt. of Sulphate of Ammonia applied, and where the land was originally poor in lime the consequence has been a souring of the earth and inability to raise a harvest from seed sown.

When superphosphate is ploughed in, the water of the soil decomposes it and spreads the phosphoric acid evenly over the acre. This does not occur with many other phosphates, and hence the advantage of using phosphates treated with sulphuric acid. The phosphoric acid is then combined with only one atom of lime and can easily be dissolved. When, however, it is mixed with damp earth it unites with three atoms of lime. It is thus not easily washed out of the soil. At the same time we find in practice that plants can make use of it according to their needs, and that it dissolves again much more rapidly than phosphates not treated with sulphuric acid.

Similarly Sulphate of Potash changes its base, the potash being freed for plant-food, and the sulphuric acid combining with the lime forms Sulphate of Lime.

Similar chemical changes explain why certain substances of little manurial value in themselves, such as common salt and gypsum, prove of great value to growing crops, On decomposing, they form new combinations in the soil, increase the amount of potash, lime and magnesia dissolved as phosphates, and often help the plant to take up more of this necessary ingredient of plant-food.

2. The physical changes brought about by manures also require careful study.

Nitrate of Soda. The Nitrate serves to nourish the plant but the Soda unites with Carbonic acid and forms Carbonate of Soda. Now it will be noticed that when clay is stirred in water the small particles remain suspended for a long time and finally collect together in little grains and settle. This is hastened if lime be added. The formaton into little masses is called flocculation, without which the soil would become sticky, like paste, hard as rock when dry, and unable to form a sufficiently stiff bed for the roots of plants, when saturated, besides being always impermeable to the air. Now the free movement of air and water to the roots of plants is necessary for vegetation, and this is almost totally impeded when crumbs are not formed. Fertilizers like Nitrate of Soda, Sulphate of Ammonia, and the potash salts also bring about flocculation, but, after they are washed out, the soil falls back more or less to very fine particles, especially in clay soils. When Carbonate of Soda is added to the soil, the tendency to fall from the crumby to the pasty state is far more pronounced, and earth containing much of it will not bear a crop owing to this deflocculation.

Farmyard manure is well known for its excellent effect in binding sandy soils and preventing the too rapid loss of water by evaporation and by drainage, while its use in heavy clay arises from its opening out the soil and thus allowing a better movement of the subsoil water upwards by capillary attraction and of the air downwards to the roots.

Long treatment with over-supplies of dung make it difficult for the water to penetrate sufficiently deep into the soil, a fact well known to market gardeners.

3. As fermenting wine causes decomposition with the formation of gases, and in bread a similar action is brought about by leaven, so in the soil we have numberless bacteria or single cell plant organisms, that, increasing by division, multiply rapidly and effect the most important changes by reducing organic matter to humus, changing nitrogenous bodies into the nitrates which the plant can assimilate and generally fertilizing the soil In their work these bacteria are considerably aided by manures, and those especially that enter the roots of leguminous plants and draw their supply of nitrogen direct from the air, are at their greatest activity when the soil is supplied plentifully with phosphoric acid and potash.

New as this may appear it only serves to explain how it occurs that soils known to be fertile have this fertility brought about.

It is extraordinary the amount of mineral matter carried away by the drainage of any large tract of land by the rivers on their way to the sea. The amount of potash thus carried away in a year in the water of the Elbe from Bohemia is, according to Dr. Aikman, 43,300 tons. Immense quantities of nitrogen are lost in the drainage waters. Faulty storing and a constant access of air to the dung-heap is often responsible for a loss of 42 per cent. of the nitrogen, with slight losses of phosphoric acid and potash.

It is not the amount of material spread over the fields that tells the quantity of plant-food placed at the disposal of plants. An ox may get a very large quantity of hay, but, if hard-worked, it requires some oilcake and other fattening and strengthening material. Though stable manure is always helpful in improving the mechanical texture of the soil and aids in the formation of humus or the upper portion of the soil containing decayed vegetation that forms the home in which the crops lived and grow, we must remenber that it is placed in the soil for its plant-food contents principally.

We must now turn our attention to the chief plant-foods it contains and compare this with other manures.

To be able to make the requisite comparison we must first understand the meaning of the word percentage. When, in Dr. Storer's analysis, we read that sheep manure contains ·69N, ·40 P_2O_5, ·75 K_2O, it means that in every 100 lb. there is 69/100 or nearly 7110 lb. of nitrogen, 2/5 lb. of phosphoric acid, and 3/4 lb. potash. We can thus make comparisons as to the amount of plant-food contained in each fertilizer, i.e., as to the substances they contain which are most necessary for nourishing and building up the plant.

In ordinary fresh stable dung we have, in Europe, ·39 Nitrogen, ·18 Phosphoric Acid, and ·45 Potash. When fairly rotted it contains ·5 Nitrogen, ·26 Phosphoric Acid, and ·63 Potash. When very well rotted ·58 Nitrogen, ·3 Phosphoric Acid. and ·5 Potash.

These figures refer to the excreta of stall-fed cattle, when the urine is carefully preserved with the dung, and care is taken that very little of the plant-food stuffs it contains is allowed to be lost in the air and in the drainage.

If we take Dr. Leather's analyses of Indian cattle dung ·3 Nitrogen, ·19 Phosphoric Acid, and ·17 Potash, we can calculate the terrible losses suffered by the raiyat owing to carelessness, negligence, indifference, or ignorance.

He knows that sheep manure is good for his fields and is careful to hire shepherds to fold their flocks where he is about to grow a paying crop.

The analysis shows how correct he is, for sheep manure contains :

	Nitrogen.	Phosphoric Acid.	Potash.	
	·69	·40	·75	per cent.
against	·3	·29	·17	,,
of Indian cattle dung or a				
difference of	·39	·11	·58	,,

or obout 2/5 lb. Nitrogen, 1/10 lb. Phosphoric acid and 3/5 lb. Potash in every 100 lbs.

We can also see the very great loss, due to ingnorance or carelessness, produced in the cattle manure carried by the raiyat to his fields.

We have seen that the dry dung alone analyses :

	Nitrogen.	Phosphoric acid.	Potash.
	·3	·29	·17
whilst the liquid excreta			
show	·58		·49

The droppings are :—

Daily

	Horse.	Ox or Cow.	Sheep.
Fresh	58 lb.	94 lb.	5 lb.
Rotted	47 ,,	69 ,,	4 ,,

or Yearly

	Horse.	Ox or Cow.	Sheep.
Fresh	21,170 lb.	34,310 lb.	1,825 lb.
Rotted	17,155 ,,	25,185 ,,	1,460 ,,

These figures are for European stall-fed cattle. About 2/3 would be the figure for working cattle.

The straw serves to soak up the excreta, and to prevent the too rapid decomposition, to raise the chemical contents of the manure, and at the same time to serve the animals as a soft dry bed.

Farmyard manure is practically the only manure in India. As cattle are not housed here in the same manner as in Europe, and the liquid from the stable goes to waste, a great proportion of what is voided, and as a rule the richest portion, is lost to the cultivator. Under such circumstances it is time that far more attention should be paid to what is saved, so that it will be utilized to the best advantage.

The money value excreted by one ox amounts, according to Dr. Richard Otto, to Rs. 62, reckoning the value of Nitrogen, Phosphoric acid and Potash on the European markets. This will scarcely be credited by the Indian farmer. Yet Otto's analysis shows how true it is.

Of 30,856 lb. voided

24,684 lb. or 80 per cent. is water,
and the remaining 6,172 „ or 20 „ is dry substance,
containing

176 „ Nitrogen = Rs. 50
74 „ Phos. acid = Rs. 3-12
200 „ Potash = Rs. 8-4,

omitting the organic substance 5,420 lb. which should be valued at Rs. 18 at least.

To this heap should be added all the materials of any use in benefiting the land.

From the analysis given before, showing the loss resulting from negligence in saving the liquid manure, we see the necessity of retaining all the fertilizing elements of the manure heap. It is therefore only what commonsense dictates to learn from those who have made a study of the losses of plant food that occur owing to incompetent management. Even in Europe the lesson wants constant repeating, and a few words from the " Farmer and Stockbreeder " will not be out of place here. "It is to be feared" the paper says, "that yet much remains to be done before farmers are brought to a knowledge of the appalling loss that takes place annually through careless and indifferent management. Experiments have been made to compare exposed and unexposed manures. It was demonstrated that there was a greater loss of nitrogen and organic matter from exposed manure than from that protected. The former lost one-third and the latter one-fifth. Ten per cent. more organic matter was destroyed in the exposed than in the protected manure. There is practically no loss of potash and phosphoric acid from protected manure.

Exposed manure that is rotting may lose about one-sixth of its phosphoric acid and somewhat more than one-third of its potash The chief changes, due to fermentation, take place within the first months of rotting, and experiments show that there is no apparent benefit in rotting the manure longer than three months."

The manure heap when kept moist loses a great deal of its potash unless the floor be watertight, and very little nitrogen escapes when the heap is kept both moist and compact. If rain comes on to the heap the water must carry away with it a great deal of soluble matter of the manure and unless the floor can stop its further progress the absorbent matter must itself drain off gradually, and money in the shape of liquid manure, finds its way into dirty puddles, proving only too clearly the definition of dirt, viz., a good thing in the wrong place. What remains in the heap is often next door to worthless, but the labour of carrying it to the fields and spreading it and ploughing it in is as great as if the best material were being used. If the manure is well pressed and the air kept out, it does not ferment so quickly, but when it is loosened and the air admitted, the oxygen of the air starts chemical and bacterial action and fermentation sets in rapidly. It should be the aim of the farmer to protect the manure from water, so that the important plant foods are not washed out; and the whole mass should be kept compact to prevent loss by a too rapid action upon it of the air. In order that the valuable liquid from the stable should not go to waste it is advisable to throw or pump it upon the heap so that it may be absorbed.

As the manure heaps are greatly neglected all over India and the loss to the poor farmer is incalculable, I extract the following interesting and instructive report by the Principal of the Agricultural School, Cawnpore, on the different systems of housing cattle and conserving manure. If the advice given be followed, it will prove of the greatest benefit to the cultivator :—

" At the Cawnpore Experiment Station this subject has been under experiment and observation during the past five or six years and the object of this bulletin is to place before the public the results of this study accompanied by such general remarks as are thought necessary for a clear understanding of the subject. Farmyard manure or cattle manure is the mainstay of farmers in all countries especially in India, where artificial or chemical manures are not practicable at present (this was written in 1901). It contains all the elements of plant-food, nitrogen, phosphoric acid and potash. It also exerts a powerful influence in improving the mechanical texture of the soil: by its application heavy clays are rendered more open and easy to work and light sands get greater coherence and absorptive and retentive powers. Of the several plant-food ingredients supplied by cattle manure nitrogen is by far the most important as it is most deficient in Indian soils, gives the quickest results when applied as manure, and is most difficult and costly to get. So the aim of every farmer should be to get the largest quantity of nitrogen in a form readily available for growing crops.

Farmyard manure consists of the dung and urine of cattle and of other farm animals. Its quality and composition will depend upon :—

1. The kind and condition of the animal producing it ;
2. The quality and the quantity of the food supplies ;

3. The care bestowed in collection and preservation.

1. *The Animal.*—Sheep yield more concentrated dung and urine than horses; horses than cattle; and cows than buffaloes. The following table shows the average amount of nitrogen in 100 parts of the excrements of these animals :—

	Nitrogen in dung.	In Urine.
Sheep	0·7	1·4
Horse	0·5	1·2
Cow	0·3	0·8

This table brings out clearly not only the difference in the composition of the excrements of the different species of animals, but also the fact that in every case the urine is much richer than the dung.

Amongst cattle themselves an adult animal gives a richer manure than a growing calf; a dry cow better than a milking or a pregnant one, because in the latter cases a part of the food is spent in putting forth the fresh growth or in forming the milk.

2. The food used in feeding the animals is a more important factor in determining the quality of the manure than even their kind or condition. The excrements of the animals of which farm manure is chiefly made up are simply the food sent out of the body after it has performed its functions. So what comes out as manure is what has been put in as food—the richer the food is, in valuable ingredients, the richer will be the manure. Foods vary very largely in their composition, i.e., in the proportion of nitrogen and other valuable ingredients they contain. The food given to cattle may be broadly divided into (*a*) grass and straw (*b*) the concentrated food generally given in small quantities at so much

a day per head, as cotton seed, rape or mustard cake, juar seed, grain, arhar, lobia, moth, etc. Practically speaking, the bulky foods of the former kinds are more or less uniform in their composition and may be taken to contain 4 lb. nitrogen in 1,000 lb. while the concentrated foods named contain about 35 to 50 lbs. of nitrogen in 1,000 lbs. Thus these concentrated foods contain about 10 or 12 times as much nitrogen as the straws, and the manure produced by an animal as well as its health and condition, will depend not so much upon the straw or fodder given to it as upon the quantity of concentrated food given daily.

This was clearly shown by the analyses made by Dr. Leather, Agricultural Chemist to the Government of India, not to speak of the countless analyses that have been made in Europe and America. He took 13 samples of dung, six of which were produced by cattle that were daily getting concentrated food in addition to their straw, the remaining seven by ordinary village cattle that depend upon grazing and the ordinary ration of straw, but get no concentrated food. It was found that the former six samples contained on the average 0·54 per cent. of nitrogen against the average of 0·17 per cent. of nitrogen contained by the latter seven samples. That is the dung of cattle that got concentrated foods contained three times as much nitrogen as the dung of cattle that did not get concentrated food. By allowing concentrated foods it is not the dung alone that becomes richer as a manure, but the urine also, and that in a greater proportion. In fact, with adult working animals the whole of the nitrogen and ash constituents contained in the food eventually comes out into the manure either through the dung or the urine. A clear grasp of this fact by the farmers of England and other advanced countries has not only contributed to their collecting and preserving the excreta of their livestock more and more carefully in proportion to the cost of the food, but has led them to purposely adopt a more liberal feeding of their stock. For they see that the money they spend in the purchase of food secures them a double advantage; stronger and more useful animals and a richer manure as well.

3. "*The care bestowed in Collection and Preservation.*"—All the dung and all the urine excreted by farm animals together with any litter that may be used, when well rotted without undergoing any loss of plant food ingredients, make the best possible farmyard manure. But in the general practice of the cultivator a great part of the dung, almost the whole of that collected during the dry months, is burnt as fuel either in his own household or sold outside to be used as such. Thereby the organic matter of the burnt dung and the nitrogen contained in it are lost. Assuming that a working pair of cattle will produce about 100 maunds of fresh dung per annum during nights and the non-working hours of the day, and assuming that the cultivator burns about ⅔ of this quantity, he loses about 11·6 lbs. of nitrogen if his cattle do not get concentrated food, and 39 lbs. of nitrogen if they do, as in the case of cart bullocks and plough catte belonging to the better cultivators in the Meerut Division.

The Urine is weight for weight, a richer manure than dung.—We have seen this already. Dr. Voelcker found one specimen of the urine of Indian working cattle to contain 1·16 per cent. of nitrogen and Dr. Leather found in another specimen that he analysed, 0·87 per cent. of nitrogen. A pair of working cattle can be taken to void about 4,000 lbs. in a year during nights and non-working hours, and this would mean about 35 lbs. of nitrogen. But the cultivator in his ordinary practice not only does not utilize it, but allows it to ferment in his sheds and become a nuisance to his cattle and the people living in his house.

The way adopted in Europe and the United States of America for securing the urine and preventing the loss of its nitrogen is the use of litter. In this country the want of bedding material is the difficulty, but this can be got over in many places by careful collection and preservation of the leaves of sugar-cane, sheesham, mangoes, jack and other trees and all kinds of vegetable refuse. The following system of housing cattle, known as the Box system is well suited for absorbing urine and supplying a well-rotted, rich farmyard manure.

Box System.—Dig the floor of the ordinary cattle shed about 3 to 3½ feet deep. Plaster the bottom and sides with clay and sprinkle a little ashes and spread a thin layer of whatever litter may be available. The manger for holding the straw and other fodder will be in front of the cattle. For a pair of cattle the shed may be about 7 feet broad and about 10 feet long. When more than a pair have to be housed a long shed of the above width may be used, allowing at the rate of about 10 feet of shed for each pair. It may be found convenient to separate the lot of each pair by two or more bamboos put across the shed. Every morning, after the cattle have gone out to work, the cattle attendant enters the shed, covers it with the dry part of the bedding and spreads about 5 or 6 lbs. of more bedding for each pair of cattle. That part of the bedding which is wet with urine may be spread likewise, before using the fresh bedding of the day. In the rainy weather somewhat more bedding will be necessary, especially when the roof happens to be leaky. The manure will go on accumulating and the box will get full in about six or eight months according to the size of the cattle and the amount of litter used. When the box is full, the fresh accumulation at the surface may first be removed and the rest of the manure dug out and carted to the field for immediate use. The manure thus made will be moist, well rotted and of a rich brown colour. In the corners and those parts of the shed where the cattle do not tread much, the manure may be dry, mouldy and very hot. A little care on the part of the cattle attendant while sprinkling the wetted straw in the mornings, and his treading these parts down with his foot, will lessen this mouldiness considerably. The unrotted top portion may be put back into the box to be taken out with the next removal of the manure. The box system of housing cattle is now frequently adopted by the most enterprising farmers of Europe and America for fattening as well as for working cattle, one of the objects being to make as large a quantity of well-rotted manure as possible: for one thing well known by the western farmers and practised by them is that if they want a large quantity of manure they must *make* it; and they can if they like. The box system has been under trial at the College Farm in Saidapet (Madras) for the last 22 years, and at Cawnpore and other experimental farms for some years. The cattle have been found to keep perfectly healthy like those in other sheds, and the objection raised against it by those who have not tried it, as affecting the feet and health of cattle, is against all experience in India and other countries. By this means about

12,000 lbs. or 150 maunds of rich manure can be made from every pair of working cattle."

A mode of conserving cattle manure that costs the farmer little money and scarcely any labour has been proved of the greatest value by the practical experiments of Dr. Schneidewind of Halle. It is simplicity itself. When carting away the matured farmyard manure, a part should be left behind and spread in the manure pit about 6 inches deep, the fresh manure is placed on top of this, and if sufficient of the old manure is left as the pit is filling, one or two layers of it must be plac d upon the fresh dung and litter that finds its way into the heap. The results however are of great practical importance, for they save a deal of manure and the nitrogenous contents of the portion left. There is always a loss in weight as the manure matures and a loss in plant food if it is not well conserved. Both these are saved, to a great extent, as the experiments show. In two well lined pits manure was gathered. In the one, fresh manure alone was placed; in the other, layers of old manure were added to the fresh. At the end of three months the results were :—

A.—ORDINARY FRESH MANURES :

In Kilogrammes	Quantity	Dry substance.	Nitrogen
At first ...	802·5	212·34	4·622
After three months	445·0	112·39	3·221
Loss ...	347·5	99·95	1·401
Loss per cent ...	43·30	47·07	30·31

B.—CONSERVED WITH OLD MANURE IN LAYERS.

In Kilogrammes.	Quantity	Dry substance	Nitrogen.
Upper layer ...	802·5	212·34	4·622
Lower layer ...	150·0	37·65	0·708
Total ...	952·5	249·99	5·330

In Kilogrammes.	Quantity	Dry substance	Nitrogen.
After three months			
Upper layer ...	430· 0	123·41	3·827
Lower layer ...	140· 0	24·64	0·720
Total ...	570· 0	148·05	4·647
Loss ...	382· 5	101·94	0·783
Loss per cent. ...	47·66	48·66	16· 94

So that the Nitrogen lost was only 16·94 per cent against 30·31 in the manure not conserved by the simple process mentioned above.

It has been calculated that the loss to the farmers in Germany arising from neglect of the manure heap, and especially from carelessness in conserving the urine of cattle, amounts annually to Rs 270,000,000.

But notwithstanding all the care and attention bestowed on the manure heap we cannot find even in Europe and America a sufficiency of this natural ferlilizer, though, owing to the stall-feeding and stabling of cattle, a great deal more of much richer manure is manufactured on the spot. In India, as every farmer knows, even the very small portion of land under irrigation cannot receive manure enough from the cattle, and if agriculture is to revive in India, recourse will have to be taken to other means of which there are a great many.

Already, around the larger towns of the Deccan, immense quantities of human excreta, formerly removed at a great cost to the municipalities, who paid contractors for the work, are now employed as a fertilizer for sugar-cane. It analyses :—

	Nitrogen	Phosphoric acid.	Potash	
Fresh, Solid and Liquid,	·85	·26	21	per cent
Removed from pits.	·37	·16	·15	„

Municipalities generally set the excreta in trenches covered with earth and when it dries it is carted away to the fields.

In the Contonment of Poona pits of convenient length and width are dug, sometimes five feet deep. Into these pits the night soil and dry pulverized earth are put in alternate layers and equal propoitions. A capital manure results, but it is not ready for several months. It is not of course so concentrated a manure as poudrette made in the ordinary Poona way. Poudrette is recognized as an active and powerful manure for all irrigated crops in which a rapid and luxuriant growth is desirable. It is very suitable for sugar-cane, vegetable and all fodder crops. It is too forcing for grain crops and fruit trees. The plant is stimulated into active growth at the expense of fruit or grain.

Poudrette is seldom applied except where irrigation is practised. It is used at the rate of 15 loads per acre, up to as much as 18 loads per acre, for sugar-cane.

Dr. Leather's analyses show that Poona poudrette contains about 1 per cent. of nitrogen, and generally a slightly higher percentage of phosphoric acid. The percentages of these ingredients vary with the percentage of moisture. The sugar-cane growers around Poona have made great use of it with resultant good crops, and the municipality have increased their income, proving again that dirt is a good thing in the wrong place when it is about the surroundings of villages and towns, and in the right place when ploughed into the fields.

There are not many fields in India so conveniently situated as to obtain any large quantity of human excreta for manure, but the usefulness of the filth of cities and its monetary value might be brought home not only to municipal towns, but to every village in the country. The question of caste will not interfere, as is well known round Poona, Ahmedangar, Madras and other Indian cities.

Though not in such enormous quantities, blood can be obtained, dried in shallow pans, and stored against the time it is needed as a fertilizer. Blood meal analyses:—

Nitrogen.	Phosphoric acid.	Potash.
11·8	1·2	0·7

showing how rich it is in nitrogen, the chief and most costly plant food. Compared with cattle manure it contains nearly 36 times as much nitrogen, so that a little over 2 lb. would contain as much nitrogen as one Bengal maund of cattle dung. It is also more active and of immense benefit to all cereals.

Hornmeal is more difficult to obtain, but contains 10·2 per cent. of nitrogen and 5·5 of phosphoric acid. The potash can always be supplied by mixing ashes or potash salts.

We see that besides the excreta of cattle there are other portions that can be used for manures when the cattle die, and one of the most important is bonemeal, so little understood throughout the country.

When I ask a farmer why he puts the leaves of trees into the soil to manure his paddy fields he says his father did it before him and everyone does it now, and it is sufficient to find good results following. He is quite right. But someone must have started usir g leaves as manure, and others began to benefit by it. Formely people travelled in bullock carts. After the railway was made this was found an easier and quicker way of getting about. When the tramway was about to be introduced into Bombay, it is said no one would buy shares in the company, as they were certain it would be a failure. The Americans who took shares knew better and it is a great success. First see if a thing is reasonable, wait, if you wish it, till you can gain by the experience of others, but then use what brings a benefit with it. To act otherwise would be foolish. The clever farmer who takes advantage of the manuring he learns from the West, will prosper; the over-conservative must be left behind in the race. Has bone been tried? Yes, not only in Europe and America and Africa and Australia, but also here in India, and always with splendid results. In Ceylon no native farmer thinks of manuring without bonemeal; but India sends one lakh of tons of bones annually to Germany, enough to fertilize with phosphoric acid 20 lakhs of acres. Is it not reasonable to use bones? The farmer uses leaves to put back in small quantities what trees have taken from the soil. Now animals feed on what the soil produces, and, to form bone, lime and phosphoric acid obtained from the plants are required, for bone is principally phosphate of lime with a certain amount of nitrogenous matter, which keeps the bones from becoming too brittle, and is also a substance of the greatest importance in manuring. This firmest and strongest part of the animal has been collected from the soil and goes back in the shape of bonemeal. Why will not ordinary bones do as manure? Because the outside of the bone is covered with a hard casing of enamel which keeps out the water, and water is required to decompose it and reduce it to the nitrogen, lime, and phosphoric acid, which from its component parts. The bone is crushed in a mill into very fine pieces, the soft parts are exposed in every direction to damp and heat, the bone decomposes, and food is placed ready for consumption by the plants.

There may be a difficulty in obtaining finely ground bonemeal. In such cases farmers are advised to have the larger bones broken into smaller pieces, and then, having dug a hole, say 6 ft. by 4 ft. by 4 ft., strew the bottom with 4 inches of earth, cover this with 3 inches depth of unslaked lime, followed by 4 inches of bone, and repeat this till the pit is filled, taking care, however, to place a few poles in the pit, so that when it is filled, they may be pulled up, and water poured in may find its way to the quick lime. In three months the bone will be powdered and the earth from the pit, with ashes, will make an excellent manure. This was tried successfully on the Demonstration Farm in the Junagadh State.

For all root crops, for the grains of cereals, for seeds of all sorts, and for fruits, the phosphoric acid contained in bones will be found of the greatest value. Bone contains about 4 per cent. nitrogen and about 23 per cent, phosphoric acid.

In combination with saltpetre, in the proportion of 3 maunds of bonemeal and 30 seers of saltpetre per acre, it produced the most astounding results on the Burdwan Government Farm. The following table speaks for itself and may possibly influence others to make a trial with the fertilizers mentioned, at least if cattle manure is not procurable, whilst others may try the different manures side by side for comparison.

Average of 12 years ending 1903.

Nature and quantity of manure per acre.	Outturn per acre.		Cost of manure per acre.		Profit per acre.	
	Grain lb.	Straw lb.	Rs.	A.	Rs.	A.
Cowdung (100 mds.)	3556	4479		6	86	5
Unmanured	1374	2174			16	7
Castor Cake (6 mds.)	3123	4628	12	0¾	50	5
Bonemeal (3 mds.)	3663	5124	5	8	80	15
Bonemeal (6 mds.)	3962	5509	11	0	84	10
Bonemeal (3 mds.) Saltpetre (30 seers.)	4389	6178	9	4	105	0

Here we see the difference between manured and unmanured land and the immense profit from a combination of two deshi fertilizers. And yet bonemeal is so little used. The German farmers, perhaps the best in the world, know a good thing when they see it, as do also German traders, with the result that about a lakh of tons of bonemeal find their way to Germany, year after year, while the general complaint of our people is that they have not manures enough for the land. In these experiments, carried out by a Native member of the Department of Agriculture, it is evident that in the absence of cowdung, excellent crops can be obtained by the use of other fertilizers, more concentrated and consequently more effective with so early ripening a crop as paddy.

The trade in saltpetre for manurial purposes is certainly not what it should be. Its development in the Panjab, United Provinces and Bengal would have the most astounding effect upon the wheat crop if bone were used with it.

In 3 maunds of bonemeal we find

	Nitrogen.	Phosphoric acid.	Potash
	10 lb.	55 lb.	—
In 30 seers saltpetre	8 ,,	—	26 lb.

For wheat a different combination of the same manures would be required. For those who do not like to use bone, other phosphatic manures, such as Basic Slag and Superphosphates are available.

Amongst the most costly but quickly acting fertilizers are Nitrate of Soda or Chili saltpetre containing 15·5 per cent. Nitrogen, Sulphate of Ammonia with 20·5 per cent. Nitrogen and the lately manufactured Lime-Nitrogen; but they are not complete manures, as they contain practically no phosphoric acid or potash.

A great number of leaves are used in the Madras Presidency as well as other parts of India, not merely as well-rotted leaf mould, but also fresh from the trees.

Tobacco stems also serve as a fertilizer; but the quantity required is more or less guess work owing to the absence of any knowledge of the analyses of the manures or of that of the crop to be produced.

When we find that the costliest manure constituent, the Nitrogen, can be obtained from the air, it appears to be the cheapest and easiest way to enrich the soil, by growing certain crops in whose roots bacteria settle and nourish themselves and the crops by drawing their nitrogenous food supply from the air, provided that potash and phosphoric acid are in sufficient quantities in the soil.

These plants when deep rooted aerate the soil and allow the water to percolate right through the sub-soil, they shade the land and thus keep down weeds, and, even when they are removed from the acre as a harvest, leave behind them large supplies of nitrogen in the nodules formed by the bacteria on their roots. When ploughed in they serve to improve the texture of the soil, as cattle manure does, and large quantities of nitrogen, phosphoric acid and potash become available to the succeeding crop. Sandy soils become firmer and receive more humus, and heavy clay soils are aerated and rendered less cold and adhesive.

Green manuring is not unknown in India, and beans, peas, etc. are frequently grown and ploughed into the soil when the flowering season begins. They certainly enrich the soil because they take their nitrogen from the air by means of the bacteria in the nodules formed on the roots ; but, till complete decomposition takes place, they return very slowly to the soil the phosphoric acid and potash taken from it to build the body of the plants. To render these of far greater use, phosphoric acid and potash should be used to manure them, the soil will improve, the crop will be far more abundant, and a far greater amount of nitrogen will be placed at the disposal of the next crop when the green manure is ploughed in. An objection to green manuring may be raised owing to the amount of acids placed in the soil with the rotting leaves. This is avoided by rotting the green manure in pits and by the use of lime on the field when ploughing in the crop.

Nowadays it is not sufficient to study merely the effects of the manures. Competition is so great that a farmer who wishes to prosper must also learn the action of soil bacteria in the preparation of plant food. These play so important a part in Agriculture that chemical analysis is considerably out in gauging the fertility of soils, and the reports arrived at by purely chemical methods give very imperfect and unreliable results. Besides the fertility of the soil as evidenced by chemistry we must take into consideration the influence of bacteria and the action of the plant roots themselves in search of their food, of which very little is understood at present. But these are subjects that require much deeper study. They are only referred to in order to show how the manure becomes more or less valuable by their action in the course of the decomposition of manurial matter. The bacteria (infinitesimally small forms of vegetable life), that cause nitrification in the course of decomposition, change the nitrogen contained in the cattle manure into the nitrogen in its saltpetre combination; but while so prepared and ready as plant food it is reduced by other destructive bacteria into the free nitrogen that finds its way into the air and is lost to the manure heap. To check the action of these latter bacteria it has been ascertained that moisture and the exclusion of air are very useful and it is on this account so much stress is laid, when treating of the manure pit, to pour on to it the urine and press the heap well down and keep it covered.

Wagner's experiments show that the nitrogen in the dung works very slowly whilst that in the urine shows immediate effects. This can easily be understood when it is borne in mind that the dung contains nitrogen which was not extracted either in the process of digestion or decomposition going on within the animal's body, whilst the urine contains nitrogen that is obtained from the changed material of the animal's body, which decomposes rapidly, and quickly forms compounds of ammonia and saltpetre. In a very short time urine exposed to the air ferments, producing at the same time ammonia.

At the German Experimental Station of Rostock a number of experiments were undertaken in successive years to show the rapid action of various forms of farmyard manure as compared with Chilisaltpetre or Nitrate of Soda, one of the quickest acting nitrogenous manures. The following figures show the results in tub experiments :—

				Straw and Corn.	
1.	Without Manure			10·0	Grammes.
2.	Standard Manure (Potash and Phosphoric acid only)			10·4	,,
3.	,,	,,	plus 0·4 grammes of Nitrogen in Chilisaltpetre	67·1	,,
4.	,,	,,	plus 0·4 grs. in Cattle Urine	52·1	,,
5.	,,	,,	plus 0·4 grs. in Cattle Dung	12·6	,,
6.	,,	,,	plus 0·4 grs. in Horse Urine	60·9	,,
7.	,,	,,	plus 0·4 grs. in Horse Dung	12·7	,,
8.	,,	,,	plus 0·4 grs. in Groundnut cake	48·7	,,
9.	,,	,,	plus 0·4 grs. in Green manure with Lupines	32·2	,,

Without further manuring the same experiments were continued next year, but the result from the dung which should have decomposed by this time, showed scarcely any better results. The above experiments were made with oats, and many practical farmers objected to it, as they said the value of dung could not be ascertained with such a crop. Trials were then made with barley, and the average returns read as follows :—

		Crop.	Crop.	Crop.
1.	Without manure	7·1 gr.	9·0 gr.	6·6 gr.
2.	Manure without Nitrogen	10·1 ,,	7·3 ,,	8·4 ,,
		allowing	per ,,	tub
	Grammes Nitrogen	·4	·8	1·2
3.	No. 2 plus Chilisaltpetre	34·2 gr.	52·1 gr.	62·3 gr.
4.	,, ,, Cattle Urine	35·4 ,,	49·1 ,,	50·1 ,,
5.	,, ,, ,, Dung	9·6 ,,	10·4 ,,	18·3 ,,
6.	,, ,, Horse Urine	37·2 ,,	52·7 ,,	53·5 ,,
7.	,, ,, ,, Dung	12·0 ,,	16·5 ,,	14·6 ,,
8.	,, ,, Sheep Urine	30·7 ,,	47·7 ,,	56·8 ,,
9.	,, ,, ,, Dung	5·2 ,,	6·1 ,,	16·8 ,,
10.	,, ,, Rye Straw	10·1 ,,	4·8 ,,	2·7 ,,
11.	,, ,, Cattle Manure i.e., Dung Urine and Straw	27·1 ,,	31·3 ,,	48·2 ,,
16.	,, ,, Leaves from the beech	6·1 ,,	4·0 ,,	8·2 ,,
20.	,, ,, Green Manure Lupines	19·4 ,,	29·6 ,,	38·2 ,,

Here we see that the dung was scarcely effective at all, the straw was positively harmful, the fallen leaves about the same, but the urine was almost as effective as

Chilisaltpetre. The cause of the ill-effect of the leaves as a nitrogenous manure is explained by Stutzer. He found bacteria that fed upon the carbon combinations in the leaves and at the same time were nitrogen consumers. Oxen, horses, and sheep consume straw and the remains of it are found in the dung. The saltpetre in the dung is changed and disappears rapidly and this can be proved by placing in horse dung a small percentage of saltpetre. By chemical re-agents it will be shown that, in the course of a few days, the saltpetre contents diminish and in about a week's time disappear altogether. That these bacteria deprive the plants of the nitrogenous food is apparent from the following table comparing the results of manuring with nitrogenous fertilizers and the excreta of cattle and of men and carnivorous animals :—

Tubs Harvest.	1st series.	2nd series.	3rd series.
1. Without Manure	33·6 gr.	34·9 gr.	26·3 gr.
2. Phosphoric acid and Potash but no Nitrogen	33·5 ,,	29·9 ,,	26·6 ,,
Plus Nitrogen	0·58 ,,	1·0 ,,	1·5 ,,
3. No. 2 plus Chilisaltpetre	74·7 ,,	88·8 ,,	71·7 ,,
4. ,, ,, Ox Urine	70·2 ,,	82·4 ,,	75·1 ,,
5. ,, ,, ,, Dung	41·3 ,,	44·9 ,,	58·5 ,,
6. ,, ,, Horse Urine	76·6 ,,	66·2 ,,	79·0 ,,
7. ,, ,, ,, Dung	15·3 ,,	10·4 ,,	8·8 ,,
8. ,, ,, Human Urine	74·7 ,,	93·8 ,,	82·7 ,,
9. ,, ,, Human Dung	69·6 ,,	64·6 ,,	80·9 ,,
10. ,, ,, Dung of Carnivorous animals (*a*)	52·7 ,,	66·0 ,,	62·1 ,,
11. ,, ,, ,, (*b*)	50·0 ,,	66·7 ,,	74·2 ,,
12. ,, ,, Stable Manure	60·5 ,,	76·7 ,,	79·8 ,,
13. ,, ,, Straw	8·0 ,,	4·3 ,,	4·3 ,,

These tables are not produced to condemn the use of cattle dung, or straw mixed with it, or to point out the excellent effects of human excreta as nitrogenous manure, but to show how little effective is the dung of cattle when used alone, and to bring home to the peasant that heaps of 'ill-prepared cattle manure may be of very little use though it is as troublesome to keep, to cart, and to spread on the fields, whilst the addition of the urine is exceedingly beneficial.

But that dung has a lasting effect upon the soil is evidenced by an experiment at Rothamsted.

The unmanured soil which produced 2,450 lbs of barely per acre for 20 years gave a harvest of 1,556 lbs. during the next five years and this average was gradually lowered to 1,300 lbs. in the quinquennial period ending with the year 1905.

At the same time land manured with dung produced 5,930 lbs. during the first 20 years, and then, though no further manure was used, produced an average of 4,732 lbs. during the next five years, which gradually fell to 2,480 lbs. in the period ending 1905.

Where dung was used every year the first ten years showed an average of 5,930 lbs., rose to 6,338 lbs. in the next quinquinnial period, and in the final period produced 6,220 lbs.

A study of the action of bacteria is most important to save a loss of the most costly constituent of stable manure, viz., the nitrogen. The straw contained in the stable manure, the dead leaves and the rubbish cast into the heap, all have not only an excellent physical effect on the soil but have also their chemical value, provided means are taken to prevent the waste in organic substance, and in plant foods, that results from carelessness in the management of the manure heap. Holdefleiss, the great German authority on cattle manure, states that by the ordinary treatment of stable manure in Europe, 37 lbs. nitrogen are lost for every head of cattle per annum, which would mean a loss, from 100 head, of not less than a wagon load, or about 11 tons of Chilisaltpetre. As mentioned before, this can be avoided, to a very great extent, by having a water-tight floor for the manure heap and pressing the dung well down to prevent the action of those organisms that require the air for their existence and deprive the manure of its nitrogen, and to encourage the work of such as do not require air to live on, cause fermentation, and help decompositon and the production of nitrogen in a form easily available for plants. This can be done by pressing down the heap and pouring upon it the liquid excrements, so that the interstices through which the air might pass become filled up.

Nitrate of Soda and Nitrate of Potash, all oil cakes, bonemeal and superphospates together with potash salts, can be ground very fine and spread either singly or mixed. The even distribution of all fertilizers is of importance so that one portion of the field may not have too much and the other perhaps too little plant food, and fine grinding helps rapid decomposition and therefore places the plant-foods quickly at the disposal of the plants.

It must be borne in mind that plants take up their foodstuffs in the liquid state and they have the power to make a selection, to a certain extent, according to their wants; though the superabundance of one mineral in the soil or the manure may result in more of that special mineral being taken up by the plant. The acids, such as phosphoric, nitric, and sulphuric, taken up by plants, in the form of salts, are found frequently in combination at times more with lime or potash or other bases, and, as the acids are principally required by the plants, the salts are taken up to invigorate the plants, leaving larger quantities of minerals which are found in the ashes. One and the same plant will have a different percentage of minerals according as it is grown in different soils.

		Lime	Potash
Thus Brassica Napus shows	on Lime soil	43·60	12·34
	on Clay	19·48	25·42
Trifolium Pratense shows	on Lime	43·32	9·60
	on Clay	29·72	27·20

We see the same with sugarcane when grown with manures containing much chloride of sodium, or in soils saturated with common salt. Such quantities of salt are taken up by the plant that, though it apparently thrives and fattens, the end for which it is grown is not attained, the sugar resulting from the crushing being so very little. It is wonderful what power the roots of a plant have to dissolve the hardest substance, for even marble gets corroded by them, but they absorb the food most handy, often taking one mineral more easily attainable than another. It should therefore be the aim of the farmer to place at the disposal of the plant all the food it requires in an easily soluble condition.

If, for instance, we place a big bone at the roots of a plant, the oily matter and the enamel prevent the entrance of water to cause decomposition; but if the same bone is dried and powdered, it is divided into so many parts that the softer portions are exposed on all sides and decomposition takes place far more rapidly.

The same care should be taken when oil cakes are used as fretilizers. The finer they are crushed and the more evenly they are scattered, the sooner will decomposition take place and allow the plants to gather the liquid food they require. The pity of it is that so much oil cake produced in the country is forwarded to Europe to feed the cattle there, whilst the cows and oxen in India are left to be satisfied with dry unpalatable grass of little nutritious worth. The oil pressed out of the seed may be exported and will fetch money. It takes practically nothing of any importance from the soil, but the residue, the cake, contains the fertilizing elements of the soil, and should be returned to the land, either dried, or through the cattle, which will benefit immensely by the food, and return to the land whatever has not been appropriated in the formation of flesh and bone. With the cry of Swadeshi ringing throughout the land, why will not the people feed their cattle with the produce of the soil, and fertilize the land with the excreta of the oxen thus improved, instead of selling these by-products for a paltry sum and seeing it shipped off to those in Europe, who know the full worth of them and take care to obtain the very best value by feeding their cattle and land at the same time.

But here we must note a most important law in Agriculture, viz., the law of Minima. Nitrogen alone would never produce a halm, a leaf, or a grain, nor would any manure or combination of manures unless every material necessary for building up the plant, such as phosphoric acid, potash, iron, and a number of other minerals, is at its disposition for food. As a rule most soils contain all these in abundance. In cultivated lands the greatest difficulty is found in supplying four viz., nitrogen, phosphoric acid, potash and lime, and we must, in speaking about manures, restrict ourselves principally to these and note their particular action. Even in grass we find all combined, for the cattle that feed upon it change it into their flesh and bone, and chemical analyses of the animal itself show that the flesh contains nitrogen amongst other substances ; the bone, phosphoric acid, nitrogen and lime ; and the hair, a great deal of potash. This is particularly the case with the wool of sheep. The dung and urine, as we have seen, also contain all these substances. If cattle are fed well, not merely on grass but with a certain allowance of oil-cakes, the farmer is aware that the animal improves wonderfully and he should learn that even the excreta of his oxen give him a far richer manure.

Below will be found a list of fertilizers which may be used on the farm, either alone or as a supplement to farmyard manure, take its place when it is not to be had, or be added in varying quantities to suit the requirements of various crops :—

Fertilizers used principally for their contents in nitrogen.

	Nitrogen.	Phosphoric acid.	Potash.
1. Chilisaltpetre or Nitrate of Soda	15·5	...	..
2. Sulphate of Ammonia	20·5	...	...
3. Lime Nitrogen	20·0	...	...
4. Blood meal	11·8	1·2	0·7
5. Castor cake	5·0	1·2	1·0
6. Coconut cake	3·7	2·0	1·3
7. Groundnut cake	7·6	1·5	1·5
8. Karanji cake	3·5	1·6	1·9

	Nitrogen.	Phosphoric acid.	Potash.
9. Mhowra cake	2·6	0·9	0·8
10. Sunflower cake	5·9	2·1	1·0
11. Niger seed cake	1·5	2·4	1·0
12. Cotton seed cake	2·5	1·2	2·4
13. Gingelly cake	5·9	1·4	3·2
14. Safflower cake	5·8	1·9	...
15. Neem cake	4·4	...	...
16. Tobacco stems	3·0	1·8	6·0

Those used principally for their contents in phosphoric acid :—

	Nitrogen.	Phosphoric acid.	Potash.
17. Bone superphosphates	0·5	20·0	0·1
18. Coprolite „ about	...	30·0	...
19. Bone ash	...	35·0	0·3
20. Basic Slag	...	17·5	...

Others that combine nitrogen and phosphoric acid :—

	Nitrogen.	Phosphoric acid.	Potash.
21. Bone	4·0	23·0	...
22. Peru Guano	12·0	9·0	2·6
23. Fish	8·0	6·1	...

Manures used for the potash they contain :—

24. Sulphate of potash	...	...	50·0
25. Muriate of potash	...	...	52·7
26. Kainit	..	...	12·8
27. Wood ashes	...	1·5	2·0

Manures containing nitrogen and potash :—

28. Nitrate of Potash or Saltpetre	13·5	...	44·0

The excreta of birds and animals contain all the elements of plant food as do most of the oil cakes which have been placed amongst the nitrogenous manures :—

	Nitrogen.	Phosphoric acid.	Potash.
Cow dung	0·3	0·19	0·1
Cow dung litter and urine	0·5	0·3	0·4
29. Sheep manure	0·69	0·4	0·75
30. Poultry droppings (part dried)	3·78	2·4	1·7
31 Poudrette	1 to 7·4	1 to 2·7	·5 to 2·7

Lime can scarcely be considered a manure in itself though it is required in fairly large quantities by certain plants, but it improves the physical qualities of the soil as it mixes with the clay and serves to break it up and render it less compact. It is also useful in depriving soils rich in humus of their free acids which are harmful to plant life. It also helps to free different plant foods and to further nitrification. After green manuring it is specially valuable. A common saying is that lime enriches the father and impoverishes the son, a saying which may be true where manuring is not resorted to.

"Lime employed without manure
Makes both farm and farmer poor."

Lime is of great value where land has an acid reaction, due to the presence of excess of decomposing organic matter yielding organic acids—a condition most noticeable on low wet lands.

As to the value of Lime we have the following expression of opinion by Paul Wolff :—

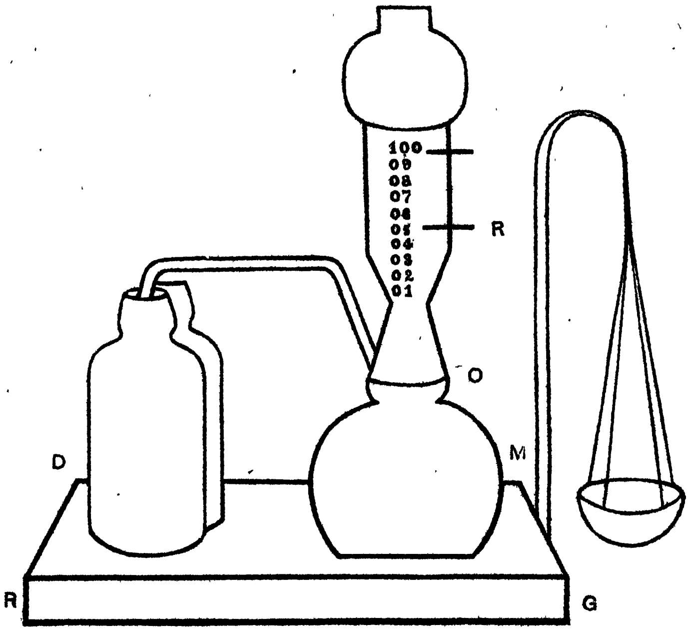
"In the use of cultural means for farming at the present time, there is a great divergence from the practice not only of former times but of only a few years ago. Our fathers and grandfathers when they wanted to increase their returns were restricted to the use of lime, marl, gypsum, and later on at the very most Peruguano and Bone meal. Now-a days a far greater number of materials are at his disposal obtainable from the soil at home or abroad, such as Stassfurt Potash Salts, Chili-Saltpetre and Raw Phosphates, as also the phosphoric acid that clings to iron and is removed from it as Basic Slag by artificial means. Many people, even the writers of Agricultural Works, place these first and mention lime last. How often do we read and hear that the chief plant-foods are Nitrogen, Phosphoric Acid, and Potash. Great essays are spun out on the subject and it is considered sufficient to say just a few words about lime. This opinion that lime is a plant-food of little value has unfortunately found its way into practical agriculture and is spreading there to the great loss of the farmer. Much has been said and written against this opinion but certainly not enough. In order to increase the harvest the question of liming the soil is at least as important as the question of Nitrogenous manuring with reference to the fertilizers mentioned above. Agriculture can be carried on, where the land is poor in lime, only where lime, in some form or other, is added. The great importance of lime in Agriculture lies in its many-sided effects, of which the following may serve in a few words to refresh the memory :—

To begin with, lime is a constituent of plant-food that cannot be replaced by any other, and is as necessary as Nitrogen, Phosphoric Acid and Potash. It is important to remember the basic property of lime to neutralise acids both in the field and in the meadow. Another very important power of lime is to render soluble many organic and inorganic components of manures and soils, and thus to place these at the disposal of plants and hasten their growth. Numberless examples from every day practice show how the addition of lime in soils poor in lime increases the returns. To take but an example,—on sandy soil on a farm in Niederlausitz the harvest was 6⅔ cwt. Rye on one hectare of land. It was considered useless for crops. However it was tried again after repeated treatment with marl, the manuring being continued, and the result was a crop weighing 11 cwt. which was increased to 16 cwt.; in other words 9½ cwt. more than was obtained formerly without lime.

From the above we can see the importance of knowing whether a soil is wanting in lime or not. This can be done by means of the Soil Tester of Professor Paul Wolff, obtainable from Messrs. Paul Funke and Co. No. 4, Chausseestrasse, Berlin, complete with scales, bottles, acid, etc., for Rs. 15. The apparatus is practical and its use simple and intelligible to all.

The bottle on D. R. G. M. should be filled with water till it stands at the black ring marking O. Now weigh 10 gr. of air-dried earth on exact scales and pour it into the bottle at the left so that none of the earth remains attached to the neck, fill the pear-shaped bottle (received with the apparatus) with muriatic acid, and from this pour it carefully, fasten the bottle and shake it till the acid mixes with the earth. Then connect it by the India rubber tube to the flask containing the measured top, and, if lime is contained in the portion of soil mixed with the acid, the water will rise over point O. and will rise by one-tenth per cent, showing the contents in lime. If the water reaches the line R on the tube it is certain the soil contains lime enough. In a few minutes a number of such experiments can be completed.

A rough sketch of the apparatus is given below:



It must be noted, however, that, though we arrive at a fair estimate as to the necessity of liming, by means of the above apparatus, different soils give up their lime for plant food, not in the proportion of their contents, but according to their texture. If a soil shows 0· 1 % of lime, it is risky to grow clover, pease, beans, etc. Where 0· 75 per cent. is discovered there is a sufficiency of lime for all plants. But the percentages between show the different action of lime on different soils. Clays containing 0· 5 per cent. lime will not grow plants that require much lime, whilst sandy soils containing as little as 0· 15 per cent. and light loams with 0· 25 per cent. show splendid growths of lime-consuming plants, whilst at the same time moor soils containing 0· 18 to

0· 20, need liming badly. When 2 per cent. of the soil is lime, the limit of benefit to be derived from it is reached. Poverty in lime is much more common than is believed. Of 1014 tests in Bavaria 304 showed that less than 0· 2 per cent. of lime was contained in the soil and consequently that there was not a sufficiency of lime.

For those, however, who cannot get chemical analyses, or the apparatus mentioned above, there are other ways of ascertaining if the lime in their soils is sufficient.

(1) The soil is poor in lime when the water issuing from it is of a brown colour as if it contained a deal of humus, and shows in the sun all the colours of the rainbow, such as are seen when kerosine oil floats on the surface of water, and also the sides of the drains show the yellowy-red colour of iron combinations.

(2) The same may be judged when on the surface or in the sub-soil grains or streaks of sand appear hardened by iron combinations.

(3) In fact where iron combinations of any sort appear on the surface or sub-soil, lime is wanting.

(4) When plants which generally grow in sour soils make their appearance, or the fodder grown is sour, though the land is not often submerged, we can judge that lime is needed.

To further test the truth of one's conclusions a very simple chemical experiment may be tried. Buy a little Muriatic acid and in stepping across the field pour a few drops on different spots. If a hissing sound is heard or the earth bubbles up, no liming is necessary: if, however, the acid merely wets the earth without the sign of a bubble, liming is required and a trial should at least be made with it.

Another easy way to determine the need for lime is to get a few pieces of blue litmus paper and place a piece in contact with the moist soil. If the soil is sour the paper will turn red, and the degree of acidity will be determined by the quickness with which it changes colour and the density of the redness. Lime also helps to keep off fungoid and insect pests. Clayey soils can stand more frequent and heavier applications of lime than soils of a lighter character, and lime tends to improve the condition of such heavy soils. According to their character soils of the lighter description are dressed with about 2 tons an acre, while cold heavy soils will take about as much as 12 tons per acre—such applications being made at intervals of from 5 to 6 years.

It is generally accepted, however, that lighter and more frequent dressings are preferable to heavy dressings at considerable intervals. The best way of applying lime is to make small heaps on the surface at regular intervals and cover these with earth. The moisture in the earth soon causes the lime to slake, and when it reaches the powdery condition it should be spread evenly and harrowed in.

In India, as a rule, most soils have a sufficient supply of lime, and, even where it may be useful, basic slag or other fertilizers that contain the lime in combination with phosphoric acid, would be far safer and more effective.

Having given the analyses of some fertilizers, it may be useful to add the analyses of harvests, so that the farmer may learn what his crops have taken from the soil and the minimum quantity that ought to be returned in the shape of manures.

It does not follow that a manuring with the exact quantity of food-stuffs taken from the soil will be the best. Much of the nitrogen, as has already been mentioned, is left in the drainage and a great deal of potash serves as a carrier of nitrogen, whilst the action of phosphoric acid is so little understood that far larger quantities are considerd necessary in practice for the perfection of many crops than the chemical analyses justify.

As the table shows, different crops remove from the soil different quantities of plant-food, and the nitrogen, phosphoric acid, and potash are in varying proportions.

Lierke's practical manure tables give the following analyses of medium crops per hectare, or 2½ acres, which would probably be far above the average in India :—

Crop	lbs.	Corn	Straw	Chaff	Nitrogen.	Phos. Acid.	Potash.
1. Wheat	,,	6,600	8,800	990	187 lb.	75 lb.	99 lb.
2. Oats	,,	5,290	7,944	771	148 ,,	60 ,,	167 ,,
3. Maize	,,	9,918	14,336	3,306	234 ,,	110 ,,	280 ,,
4. ,, kadbi (green)	,,	110,200			209 ,,	115 ,,	405 ,,
5. Potatoes 55,100 lb. tubers 6,612 lb. leaves					212 ,,	97 ,,	339 ,,
6. Meadow grass 13,224 lb. hay					205 ,,	55 ,,	209 ,,
7. Tobacco 3,967 lb. leaves 3,306 lb. stems					218 ,,	55 ,,	256 ,,
8. Grape Vines					139 ,,	46 ,,	150 ,,
9. Onions		66,120 lb.			178 ,,	90 ,,	178 ,,

According to the *Queensland Agricultural Journal*, the following crops take from an acre the quantities of plant-foods mentioned in the table below :—

	Nitrogen.	Phosphoric acid.	Potash.
Sugarcane ...	127 lb.	44 lb.	298 lb.
Rice ...	41 ,,	26 ,,	68 ,,
Cotton ...	54 ,,	19 ,,	40 ,,

Of plants that make an excellent green manuring a few analyses of harvests may be given, so that farmers using such fertilizers may fully understand their value. According to Lierke, a medium crop per hectare, or 2½ acres, would remove :—

	Nitrogen.	Phosphoric acid.	Potash.
Lucerne 70,528 lb. green or 17,632 ,, hay.	507 lb.	114 lb.	320 lb.
Lupines 22,000 ,, green or 5,500 ,, hay.	330 ,,	68 ,,	95 ,,
Horse beans	454 ,,	114 ,,	302 ,,
Pease	275 ,,	70 ,,	123 ,,
Clover	467 ,,	335 ,,	405 ,,

Most of the nitrogen from the harvests above mentioned was taken by the crop from the air, so that by an expenditure of from 68 to 335 lb. of phosphoric acid and 95 to 405 lb. of potash the gain in nitrogen was from 275 to 507 lb. or the amount contained in 41 to 75 tons of dry Indian cattle dung ; and nearly all this is gathered from the air.

By comparing the food stuffs taken from the soil in the foregoing tables with what can be supplied by cattle manure, we arrive at not only the quantities required, but also at the difficulty to supply these without wasting one food stuff while supplying a sufficient quantity of another. Take for instance, sugarcane : to supply by cattle manure alone the great amount of potash required by the crop, enormous quantities would be required, and a great waste of nitrogen would result.

With all leguminosae, to place at the disposal of the plants the requisite phosphoric acid and potash, stable manure would cause a woeful waste of nitrogen, and probably be productive of more harm than good, for the bacteria at the rootlets, instead of then obtaining nitrogen from the air, would be satisfied with the nitrogen of the fertilizer.

A great many Indian farmers know from experience that cattle dung, far from being beneficial to leguminosæ, such as groundnuts, is often prejudicial, almost always a waste. They may not know that the bacteria found in the nodules at the roots of the plant draw down the nitrogen from the air and thus feed themselves and the plant together, but they do not see the necessity of using farmyard manure, and, in consequence, use no manure at all. But it should be remembered that for every pound of nitrogen absorbed by the leguminosae they ruquire about one pound of potash and about a pound and a quarter of phosphoric acid, so that the common saying that these plants " leave the soil better than they found it " is only correct when a sufficiency of phosphoric acid and potash is added to the soil in the form of fertilizers. This will be clearly understood when we analyse a clover crop and see what it takes from the soil. Most of the nitrogen may come from the air, but the phosphoric acid and potash come from the soil, and when the crop is removed, the soil is poorer by just that amount of phosphoric acid and potash.

At Rothamsted the benefit to the soil of leguminous crops not ploughed in was tested by a comparison of two plots, one under lucerne, the other under wheat for eight years. The lucerne crop contained 13 times as much nitrogen as the wheat crop, yet the former plot contained in an acre of soil 524 lbs. more nitrogen than the latter plot at the end of the experiment. In other words the added nitrogen obtained from the air was equal to a dressing of 30 cwt, of nitrate of soda worth about Rs. 290.

One kind of manure contains a particularly large supply of one kind of plant-food which it can supply. One manure may give large harvests on one field or with one crop to which it supplies just the kind of plant-food that is missing or most required, while it will fail to produce an equally good crop on another field however much it may be applied. For this and other reasons the one-sided or special fertilizers are not used much in countries in which agricultural chemists have not been at work. As a rule only such manures find favour there which supply all the plant-foods wanting. We may therefore call these manures complete manures to distinguish them from the one-sided or special fertilizers which supply principally one or, at most, two kinds of plant-food. These complete fertilizers we find in excreta from domestic animals. They, in their food, have obtained the principal plant-food ingredients, and these appear in what has been voided. But the plant-foods are present in very small quantities, and as crops vary in the amounts of different manurial ingredients taken from the soil, it is often advisable, sometimes necessary, to add to this natural manure varying quantities of artificial fertilizers, and where the natural manure is deficient, to supply its place wholly by them. For this small quantity of special fertilizers supplies what happens to be deficient in the general fertilizer, and, having a comparatively large percentage of this one constituent, is equivalent to a large quantity of the general fertilizer with which it is mixed. Thus one pound of bone meal containing 20 per cent. phosphoric acid may be 50 times as valuable as a cattle manure containing 0·4 per cent. of phosphoric acid, and one pound of muriate of potash containing 57 per cent. added, may be equal to 285 pounds of manure containing in addition to 0·2 per cent. of potash, 0·4 per cent. of phosphoric acid and 0·5 per cent. of nitrogen. If, however, the soil were equally deficient in both these constituents and nitrogen as well, no amount of ashes or superphosphate would do much good by themselves. It would require ashes and superphosphate, and perhaps *poonac* as well. In that case about 1 pound of bone meal, two pounds of ashes (at 5 per cent. potash) and 4 pounds of poonac would contain the plant-food found in 50 pounds of cattle manure having the composition given above. Therefore, even if all the constituents of plant-food supplied by cattle manure are deficient in the soil, we may still replace or augment cattle manure if we desire to do so. There are, of course, other special manures to replace these, such as saltpetre for potash and partly for nitrogen, fish for nitrogen and phosphoric acid, poonacs, bone meal, dried blood meal, and the various potash salts, nitrate of soda, etc.

It must be borne in mind that, according to Liebig, " the plant does not live on single food ingredients, but on a nourishment composed of different food-stuffs and every single constituent part of this nourishment is effective only in the completed whole."

According to the Law of Minima, if one plant-food constituent is missing no crop will result, and where one constituent is found in the soil or the manure or both combined, in an insufficient quantity, the harvest will fall in proportion as that particular constituent is wanting, notwithstanding a superabundance of all the other constituents. Suppose for instance the soil contains—

Potash enough for	30	cwts.	of	paddy
Lime ,, ,,	50	,,		,,
Phosphoric Acid	25	,,		,,
Nitrogen ,, ,,	15	,,		,,

the harvest will be 15 cwt. of paddy, even if large quantities of phosphoric and potassic manures were added. Similarly if nitrogen were added in manure, sufficient to produce 100 cwts., the crop would increase to only 25 cwt., and if the phosphoric acid supply were multiplied by four, the amount of paddy obtained would not exceed 30 cwts. For the potash in the field would be enough for that amount only, and not one pound more could grow without an increase in the potash placed at the disposal of the plant.

For a crop of 10 tons of potatoes the nitrogen taken from the soil is 85 lb., the phosphoric acid 39 lb. and the potash 136 lb. Now suppose ordinary farmyard manure were used on land devoid of all plant-food the amount required to supply the nitrogen at 0·5 per cent. would be about 7½ tons. This, however, at 0·4 per cent. would yield only 68 lb. of potash, and the result would be that instead of a crop of 10 tons the harvest would be only 5 tons, even if enormous quantities of nitrogen and phosphoric acid were added to the manure.

The plant will respond fully to a complete manure, i.e. to one that contains all the food constituents required by the crop in sufficient quantities ; or, in other words, if you require an excellent crop, without waste, you must have a full, complete, and well balanced fetilizer.

Professor Paul Wagner of Darmstadt has reported upon the increased harvests arising from heavy manuring with phosphoric acid. The experiments were carried out since 1898, with the greatest care and exactness. In 1898 the harvest from the unmanured plot was 26 cwt. of corn from rye, per hectare. The application of 6 cwt. of nitrate of soda and 12 cwt. kainit produced no increase for the crop amounted to only 25·6 cwt.—practically the same as the unmanured plot. As soon, however, as 17 cwt. of 16 % basic slag was added to the nitrogen and potash combination, the complete manure produced 51·8 cwt. of corn. The increase of no less than 26·2 cwt. of rye corn, with proportionate straw, was obtained by the addition of the slag, the constituent of plant-food necessary to complete the manure, showing that the soil was sadly wanting in phosphoric acid.

Calculate the Nitrate of Soda at 40 marks, kainit 18 marks and basic slag 32, total 100 marks. Against this we have 261 marks for 12·9 cwt. corn and 28·8 cwt. straw, so that the complete manure produced a net profit of 151 marks.

This is a most important point to consider in farming, for, as in all other business carried out in a proper manner, there should be no waste, and yet the best possible returns must be obtained at the least possible expense. One of the means of obtaining this end is to procure cattle dung containing large quantities of nitrogen, or, better still, a fair amount of phosphoric acid and potash as well as nitrogen. But this seems absurd, the peasant will say. How can we regulate what the cattle will void? It is not absurd, and it is easy to regulate it. A careful feeding of the farm cattle not only improves the animals in every way, but also gives a return in excellent manure. If they are fed on hay and hay alone, what is voided contains the greater part of what has been consumed. But hay is poor in food constituents of plants, and what is voided must be similarly poor. Every peasant knows that when a cow or ox is well fed it increases in size and weight and strength, and most farmers give the animal a supply of oil cakes after a hard day's work. But few know that there is a good return in the dung and urine. What happens? The animal consumes various foods which are changed within it to produce bone and flesh and muscle. The plants themselves on which it feeds have gathered their substance from the dead earth and formed them into the substance of plant life. Plants take varying quantities of different foods from the soil. Sugar-cane is a greedy eater and demands large amounts of nitorgen, phosphoric acid and potash to satisfy its hunger; the groundnut, on the other hand, though it requires an application of phosphoric acid and potash, does not need a supply of much nitrogen, in the soil, for it absorbs the nitrogen of the air by means of the bacteria gathered in the nodules at the roots. All leguminous plants feed in the same manner on nitrogen derived from the atmosphere direct. You can generally know these plants from the shape of the flowers, that are termed papillonaceous, because they resemble butterflies. Now these plants give a supply of cheap nitrogen for the fattening and strengthening of cattle and they do more.

According to the experiments of Henneberg and Stohmann the quantity of excrement voided by an ox 2,200 lb. in weight was—

	Fresh.	Dry.
Dung	93 lb.	16 lb.
Urine	40 „	2·2 „

when fodder was consumed that neither added to nor caused any reduction in weight ; but when concentrated foods were used the amount voided was .—

	Fresh.	Dry.
Dung	111 lb.	17 lb.
Urine	70 „	3 „

And the difference in the nitrogenous contents was :—

With the former food	...	·48 per cent.
With concentrated food	...	·79 „

It is evident from the figures given above that both the quantity and the quality of the matter voided depend entirely on the food supplied.

What the animal eats serves to produce animal substance such as flesh, bone, milk, hair, etc., or is used up in breathing and sweating, and, what is no longer required by the system is voided as dung or urine.

Whatever is not digested passes away as dung, while the urine is the product of what has been taken into the system, changed for the most part, and later on voided as useless. Extraordinary though it may appear to the peasant, not a particle of what is useful in the food is lost, for what does not go to build up the body of the animal is returned in the excreta, especially the nitrogen and the ash components of the food. In breathing and perspiring, carbonic acid, and water are used, and these are of very little importance in manures.

How much is returned to the land by the careful feeding of cattle will be easily understood when it is borne in mind that, though young growing cattle excrete only 30 per cent. of the nitrogen in their food, a milch cow will return 75 per cent. in the dung and urine, and a fattening bullock about 95 per cent. Of this the urine contains three times as much nitrogen per cent. as the solid excrement.

From this we can calculate the valuable materials gained in the manure when we know the analysis of the food consumed and take into consideration the animal substance gained.

Poor feeding means poor cattle manure, poor cattle manure, starved fields, and starved fields, starved farmers. Fields that are badly manured can be vastly improved by attention paid to the feeding of cattle.

Comparing the analysis of different manures, we see that, though natural manures such as the excreta of animals and men and the composts made up of stable manure and the waste products of a farm are exceedingly useful, both form their value as plant-food and the effects they have upon the mechanical improvement of the texture of the soil, there is, as a rule, too little ot it to fertilize even an infinitesimal portion of the fields in India. We also know, in many cases, that crops requiring no supply of nitrogen in the soil, such as the leguminosæ, but needing fair quantities of phosphoric acid and potash, cannot be brought to their fullest bearing by the use of cattle manure, and its use would probably be a sorry waste.

If we can obtain nitrogen free from the air it is to our advantage to do so. We accomplish this by growing leguminous crops and ploughing them in before they run to seed, so that all the nitrogen collected in the plant by the bacteria at the rootlets may be kept in the soil and prove a fruitful source of food for the next crop. This is called green manuring, and is always more successful when phosphoric acid and potash are placed at the disposal of papillonaceous plants. It is therefore plain that such crops require some manure different to cattle dung in order to arrive at their full development. In such cases a bag of bone meal or superphosphate and a hundredweight of potash salts would be of far more benefit than many tons of stable sweepings.

Besides this, as the analyses show, stable manure though a complete manure containing all the necessary foods required by plants is not always a well balanced fertilizer.

Some crops require large quantities of nitrogen for their perfect development, others need more phosphoric acid, and others again more potash, while some can do without nitrogenous supplies in the soil, but must have phosphoric acid and potash to enable them to draw their nitrogen from the air. Here we see the value of many incomplete but exceedingly useful fertilizers, such as supply one or more but not all the cheif ingredients required by plants.

We therefore divide manures into complete and, incomplete and in order to balance them well, i.e., to place at the disposition of the plants the food they require for their perfect growth, we add one or more of these to the animal excreta used, or mix them in such proportions as to place in the soil the ingredients that are likely to result in a bumper harvest.

In America, the hard-headed business-like Yankees saw miles of sand in Florida, apparently of no earthly use for Agriculture. Good drainage was there, which the pine-apple needs. The food could be supplied by artificial fertilizers, and the land was pitched upon for the purpose, with the result that car-loads of excellent fruit, fresh and canned, are now sent out from this once arid spot. The majority of soils in Florida on which oranges are grown are largely sandy; in very many cases, indeed they are almost pure sand as deep down as one can go. A chemical analysis of the soil of one good grove gave ninety-nine per cent. silica, or pure sand. Oranges grown on such soil are, as the scientist would term them "sand cultures," and all the essential elements of plant-food must be added artificially. The experienced Florida orange grower is an expert in the use of commercial fertilizers. He will tell you to use a fertilizer composed of three to four per cent. of nitrogen, five to six per cent. phosphoric acid, and ten to twelve per cent. or more of potash. He can tell you all about the solubility or insolubility of phosphoric acid fertilizers, the necessity of using large quantities of potash, etc. He recognises that excessive quantities of potash fertilizers tend to produce sweet fruits, and that excessive quantities of nitrogenous fertilizers produce a rapid, vigorous growth of the tree, and a puffy, sour fruit. In the same way the very best tobacco is grown on soil so sandy and devoid of plant-food that, without the aid of artificial fertilizers, nothing would thrive, and n the Malay Peninsula even sugar-cane, which every Indian knows requires a good soil and heavy manuring, has been grown in almost pure sand, the Chinese using the refuse of the indigo vats as a bed for the stools. In none of these cases could cattle manure be obtained in sufficient quantities, and the crop of tobacco would certainly not have paid, not merely on account of the cost of cattle manure, if it could be obtained, but from the lowering of the quality by its use in quantities too great.

The same benefits can be derived in all parts of India from the use of artificial fertilizers, and in many places, especially where hundreds of thousands of acres of *reh* land are to be found, nothing else will serve to obtain a crop of any sort. A few words on these fertilizers, which to many in India are absolutely new and whose names even are as strange as Chinese, may not be out of place here.

Among the artificial fertilizers used principally for their nitrogen, the best and costliest are nitrate of soda and sulphate of ammonia.

Nitrate of Soda or Chilisaltpetre is a hydroscopic salt, i.e., it takes in the vapour from the atmosphere and must consequently be kept in a dry place or it will become so watery as to lose much of its nitrogen. When chemically pure it contains 16·47 per cent. nitrogen, but, as a rule, what is sold in the market contains from 15·55 to 15·81 per cent. This salt dissolves easily but is not long retained by the soil, finding its way very early downwards and thus being easily washed below the humus where it is lost to the roots of the plant. Care must consequently be taken to spread it just when it is wanted, and it must not to be ploughed into the soil but must be used as a top-dressing only. As soon as the salt dissolves in water it is food ready for plants and is greedily absorbed. What is not taken up by the roots finds its way into the subsoil and thence into the drainage. For all cereals it is an excellent manure, and very small quantities are required to produce bumper crops, provided the law of minima is borne in mind and a sufficiency of available phosphoric acid and potash are in the soil or placed at the disposition of the plants by means of fertilizers. The salt is obtained in large beds on the coast of Chili and Peru, but must be carefully purified chemically, as it contains many impurities, one at least of which is deadly to plant life. From the Report of the Chilisaltpetre Commission in Germany, the following extract is of importance:—" During the last few years more or less extensive harm was done in various districts by fertilizing with Chilisaltpetre or Nitrate of Soda. In 1896 a number of cases were published in which injury was done to the crops because too great a percentage of perchlorate remained in the fertilizer sold, and Dr. Maercker went further into the question. Hamburg importers offered to give compensation if more than ¾ per cent. perchlorate were found, but this did not suit the purchasers whose crops might be ruined, whilst they would have to be satisfied with about 8d. per cent. compensation. The commission finally appointed by importers and purchasers decided that no more than 1 per cent. of perchlorate as a maximum should be permitted in the sale of Chilisaltpetre as plants are sensitive in various degrees to its ill-effects. This guarantee should accompany every bag. Being a coarse-grained salt it can easily be adulterated with common salt, Kainit (which it resembles closely), Sulphate of Magnesia, etc.

One cannot be too careful to ascertain the names of respectable dealers and have a guarantee of the purity of the article bought. It is very poisonous to animals and should be kept very carefully out of their reach.

The chemical nomenclature of Nitrate of Soda is generally written $NaNO_3$ and its contents in Nitrogen 15·51 to 15·81 per cent.

As far back as 1888 we have comparative experiments that show the benefit of Nitrate of Soda when a sufficiency of potash and phosphoric acid are in the soil.

	Corn	Straw
At Woburn without manure the harvest was	9 bushels	14 cwt.
By the application of 2½ cwt. Nitrate of Soda	20 ,,	22 ,,

With cereals an application of this fertilizer very often doubles the return, which can be still further increased by completing the manure.

The extent to which Nitrato of Soda is used in Agriculture and its growth in popularity is evidenced by the following figures showing the exports from Chili :—

In 1830	...	800	tons were exported.
1870	...	136,287	,, ,,
1890	...	1,050,119	,, ,,
1906	...	1,707,475	,, ,,

Though Sulphate of Ammonia contains a greater percentage of nitrogen it does not appear, when used alone, to place the nitrogenous plant-food so quickly at the disposition of the plant unless soda or potash be mixed with the fertilizer. It is obtainable on a large scale by adding sulphuric acid to gas water, which contains a deal of ammonia. When horn, hide, or coal is heated, the decomposing animal or vegetable matter gives off nitrogen, and, as coal contains about 2 per cent.

of nitrogen, immense quantities are got in the process of obtaining gas from coal. Chemically pure it contains 21·2 per cent. nitrogen, but the sulphate of ammonia of commerce contains, as a rule, about 20 per cent. As with Nitrate of Soda, one must insist on a guaranteed analysis of purity, for it may possibly contain free sulphuric acid and rhoden and cyanogen compounds. The last two are deadly poisons for plants, and the sulphate of ammonia should be entirely free from them. Like Nitrate of Soda this fertilizer is of importance in all soils poor in nitrogen and for all crops that require a large supply of easily available nitrogen. It need not be ploughed in. To harrow the field after spreading the fertilizer will be sufficient. As Sulphate of Ammonia it cannot be assimilated by plants. In warm weather, when there is a sufficient supply of lime in the soil it changes rapidly into nitrates and consequently acts nearly as quickly as Saltpetre in building up the leaves and body of the plants, so that, whenever it is found necessary to ensure a rapid development and increase of leaf and stem, Sulphate of Ammonia is used as a manure.

In light soils its effects are better than Nitrate of Soda if heavy rains follow its use, for the latter is lost to a great extent in the drainage. Of course both these fertilizers act upon the single crop for which they are used and do not give returns for any further rotation.

Sulphate of Ammonia is now rapidly coming into favour. Its manufacture in Great Britain alone which in

1872	was	42,000 tons
	rose in	
1902	to	220,000 ,,
	and in	
1906	to	289,000 ,,

Sometimes Ammonium Sulphocyanate is found in it. As this is poisonous to plants Sulphate of Ammonia should be tested with perchloride of iron. When the Sulphocyanate is present it presents a red colour.

The constant use of Sulphate of Ammonia causes a loss of the very necessary lime of the soil. The Ammonia is changed into nitric acid, which, with the sulphuric acid, is neutralised by lime. The Nitrogen is either taken up by the plant or washed away in the drainage, and the carbonate of lime is similarly lost. Among root crops it has been found far more effective with potatoes than Nitrate of Soda.

As was said before, and cannot be too often repeated, provided all the other ingredients are either in the soil naturally or placed there by fertilizers, the use of single manures such us Sulphate of Ammonia for its nitrogen proves exceedingly beneficial.

In Java for instance—

	Weight of cane in lbs.	Sugar obtained in lbs.
An unmanured field of $2\frac{1}{2}$ acres produced ...	179,348	22,970
With an application of 778 lbs. of sulphate of ammonia the crop was increased to ...	257,990	28,868

Lime Nitrogen has been manufactured of late. It contains 20 per cent. Nitrogen and 21 per cent. Lime and acts as a plant-food, like Sulphate of Ammonia. When the guano deposits were becoming exhausted great demands were made for the Nitrate of Soda found in the dry regions of Chili, and hence called Chili saltpetre. Immense quantities of this are sold every year at a high price, and chemists endeavoured to manufacture something as efficient in plant feeding. They saw no reason why the nitrogon should not be extracted from the air, and succeeded in obtaining it.

If air is passed over metallic copper, heated to 400°C. the oxygen unites with the metal, forming copper oxide, and the nitrogen gas is freed from its mixture in the air.

In the meantime, by heating chalk and coke in an electric furnace, calcium carbide is formed. It is known to many bicycle riders who use acetylene gas lamps. This carbide is finely ground and placed in iron tubes, which are heated to a temperature of 900° C., and then the free nitrogen is passed over the carbide and a chemical combination takes place the carbide uniting with the nitrogen and forming calcium cyanamide, in chemical notation $CaCn_2$. It slowly reacts with water, forming ammonia and lime, according to the following chemical equation :—$CaCn+3H_2O = NH_3+CaCO_3$.

It is hygroscopic to a great extent, i.e., it greedily takes up moisture from the air, and is consequently sold in air-tight drums.

It is a fine powder, of unpleasant odour, and is generally mixed with damp earth before it is spread. The fertilizer should be ploughed in and never used as a top-dressing if there is danger of its coming into contact with the leaves of plants which it burns. It is also said to be hurtful to sprouting seeds, and the recommendation is not out of place, to put it into the soil a month before sowing the seed.

Wagner says that its action is uncertain in sandy and peaty soils, which may be due to the absence of decomposing bacteria, but in loamy and clay soils it is an excellent nitrogenous manure, which also supplies lime where it is wanting.

There is another fertilizer prepared in the same manner, except that Chloride of Calcium is added to the Carbide. It is called Nitrogen Lime.

Professor Dr. Immendorf of Jena in a German Agricultural Association Bulletin says :—It should not be used for sour humus soils. Its effect there would be doubtful, sometimes poisonous, nor on poor light sandy soils. It is always good on other soils on which 150 to 300 kg. can be used per hectare. When the surface of the soil is hot and moist, it should not be spread or it would not get evenly mixed.

It contains 20 per cent. nitrogen and 21 per cent. caustic lime.

Blood meal when pure contains 14 per cent. nitrogen, though it is found in commerce, containing as low a percentage as 9. In India it is usually prepared in broad shallow pans placed out in the sun to dry. On light soils it is usually preferred to Sulphate of Ammonia and Nitrate of Soda as the nitrogen is not so quickly lost in the drainage. It must be ploughed into the soil and not merely used as a top-dressing. Its effects last for about a year. In moist warm weather it decomposes rapidly, forming at first ammonia and then nitrates.

In experiments with tobacco made in Virginia, dried blood for nitrogen gave the largest yield, and in all cases the tobacco ripened from 10 days to 2 weeks earlier.

Though not frequently for sale, horn and leather meal are excellent nitrogenous fertilizers, the first containing, when pure, 13 to 14 per cent. nitrogen, the latter 11 to 12 per cent. Of course the action is slower than that of the fertilizers mentioned before. From 50 to 70 per cent. is at the disposal of plants the first year and the balance shows its effects the next year.

With all these purely nitrogenous manures the increase in leaves and green matter is decided, but the produce in corn is not great unless similarly effective phosphatic and potassic manures are employed in suitable quantities, and the more of the latter two are employed, the better will be the harvest. The nitrogenous manures, which are the more costly, are spread in quantities sufficient for the crop to avoid loss; the other fertilizers are not so rapid in their action and consequently should be used in larger quantities. Comparatively small quantities are lost in the drainage, as they are absorbed and retained by the soil.

In Professor Heinrich's "Duenger und Duengen" (Manures and Manuring) he gives the result of pot experiments with nitrogenous manures (a sufficiency of phosphoric acid and potash having been added to the very poor sandy soil used).

(The plants fertilized with Chili saltpetre became mildewed and are not included in the table.)

	Average Crop		
Manure.	Straw & Chaff.	Corn.	Total.
Without Nitrogen	1·5 gr.	1·0 gr.	2·5 gr.
Sulphate of Ammonia	6·7 ,,	6·8 ,,	13·5 ,,
Flesh meal	5·3 ,,	4·4 ,,	9·7 ,,
Bone meal	4·7 ,,	4·0 ,,	8·7 ,,
Leather meal	4·4 ,,	3·5 ,,	7·9 ,,
Blood meal	4·3 ,,	3·5 ,,	7·8 ,,
Horn meal	2·3 ,,	2·1 ,,	4·4 ,,

The above table shows that Sulphate of Ammonia s immediately efficacious, whilst the various other nitrogenous manures come into operation more slowly, as the decomposition is not so rapid, and the nitrates are consequently placed more slowly at the disposition of the plants. Nitrate of Soda is, as a rule, still more effective than Sulphate of Ammonia. The crop was of oats; the sowing took place on 26th April and the weighment of the harvest on the 23rd July.

Nitrate of Potash or Saltpetre is found as an efflorescence on the soil in India and other dry tropical countries. The plains of Bengal produce a quantity estimated at 20,000 tons per annum, which is used in the manufacture of gunpowder. Most of the Nitrate of Potash in commercial use is prepared artificially. Animal and vegetable matter decompose, nitric acid is freed, and, uniting with ashes, forms Nitrate of Potash, designated chemically KNO_3. It contains not only 13 to 14 per cent. Nitrogen, but also 43 to 45 per cent Potash, and is consequently a very valuable manure, not much used in Europe on account of its cost, though here in India the price is moderate enough to make it pay well. It is now generally sold very impure, but in course of time, as artificial fertilizers come upon the market, will probably be accompanied by certificates of guaranteed analyses. The Nitrogen is soon used up by the crop, but the potash remains in the soil, and its use on the Burdwan Government Farm has been productive of extraordinarily rich returns. It is not a complete manure, as phosphoric acid is required, but the application of from 1 to 2 cwts. of bone meal must render it complete, and it supplies such large quantities of Nitrogen and Potash that it cannot be too highly recommended.

Another manure that contains a fair amount of nitrogen and a very large quantity of phosphoric acid is bone meal, which analyses N (Nitrogen) 4 per cent. and P_2O_5 (phosphoric acid) 23 per cent.

Owing to the relatively great drain on the soil of phosphoric acid, so needed by all plant-life, many soils are very deficient in this substance, and this is patent from the increase obtained generally by an application of phosphatic manures.

Phosphorus or phosphoric acid would be a poison to plants: but taken up in the form of salts or phosphates, it has been found exceedingly useful for the growth of grasses, leguminosæ, and more especially for cereals, where it is little required in the straw and plentiful in the grain, the latter improving greatly in quality and quantity by the use of phosphatic fertilizers.

Professor Dr. Holdefleiss in the year 1890 wrote as follows :—" It is a constantly recurring thing to find a farmer, who wishes to sow wheat, cover one part of the field with stable manure, and the other part with bone meal. No man with a farmer's eye, who has seen wheat produce by bone meal alongside that produced by farmyard manure, can possibly place bone meal on the despised level to which Wanger has relegated it. There is no use bringing forward cleverly arranged experiments to prove its inefficiency, when the lie direct is given to the arguments by numberless repeated agricultural observations and experiences."

In the experiments with rye carried out at Horn, (Hamburg), the following results tell wonderfully in favour of bone meal as a manure :—

Plot	Grain lb.	Straw lb.
1. Unmanured	1,014	2,907
2. With farmyard manure	2,149	5,301

Plot	Grain lb.	Straw lb.
3. The above plus 600 lbs. steamed bone meal	3,250	7,925
4. Farmyard manure plus 900 lbs. basic slag	2,118	5,331
5. Farm-yard manure plus 600 lbs. Peru Guano treated with Sulphuric acid.	2,880	7,944

The whole development of Agriculture in Silesia appears to have originated with the plentiful use of this fertilizer.

But we need not go far from India to learn of the benefits to be derived from its use.

In the warm climate of the tropics, where there is a sufficiency of moisture, the results are still more striking.

The Celyon peasants pay often as much as Rs. 80 per ton for bone meal, and never think of growing a rice crop without it, and in India the verdict is pronounced in the following words of *Indian Gardening* :—" We are constantly being asked by our readers whether we consider bone meal (or bone dust) to be a good manure, whether it should be used in a fine or a coarse state, and whether it is good for this or that crop. To begin with, bone meal as a fertilizer scarcely has an equal ; mixed with saltpetre, cow dung, castor cake, or linseed cake, it has been found to produce very heavy outturns when used for field crops. For coffee it has been found to give excellent results, either alone or when mixed with other manures. In the case of tea also it has been known to give very satisfactory results."

The experiments on the Government Farm at Burdwan speak distinctly in its favour, especially when used for rice with Nitrate of Potash or saltpetre.

In England bone was used as a manure so far back as the end of the 18th century, and to this day bone meal and phosphate made from bone meal are perhaps the most popular manures in the country. These have proved valuable manures and the farmers consider them safe. Supplies arrive principally from India and Argentina, whilst some are imported from Egypt, Morocco, Brazil, and the Continent of Europe. The consumption in England alone of manures made from this source amounts annualy to 100,000 tons. Much depends upon the fineness of grinding, but, when a meal approaching dust is made from bones, the effect is almost as good as that of superphosphate. To act quickly bone meal should be chosen that can pass through a sieve containing holes $\frac{1}{30}$th of an inch in diameter.

In hot countries, where moisture is great, the decomposition of bone is rapid, but it is much slower in temperate or cold climates, where, as a rule, bone is used after being treated with sulphuric acid. It is then called superphosphate, and the phosphoric acid being soluble in water is easily and quickly taken up by the rootlets of plants. Superphosphates are also made from coprolites, the petrified dung and remains of carnivorous animals, which are dug up in enormous quantities in America.

But, before treating of superphosphate, we must speak of another nitrogenous manure containing a heavy percentage of phosphoric acid. On various islands frequented for centuries by myriads of sea-birds the dung has accumulated to such an extent that shiploads are removed to all parts of the world to serve the purpose of fertilizers. This is called Guano.

Guano still reaches England from S. America, Australia and S. W. Africa, and in 1907, 31,278 tons were imported.

Guanos vary in analysis.

Peruvian Guanos contain :—

Nitrogen	...	$2\frac{1}{2}$ to $11\frac{1}{2}$ per cent.
Tribasic Phosphate of Lime		15 ,, 42 ,,
Potash	...	2 ,, 4 ,,

The Chinchas Islands guano, analysing 14 to 16 per cent. nitrogen, 12 to 14 per cent. phosphoric acid and 2 to 3 per cent. potash, was soon used up, for the 10 million tons could not last long with a demand of 500,000 tons per annum.

As it was in very great demand its price increased far beyond its value to the farmer, and adulteration began, with the result, that every consignment required careful analysis, and only on the declared analysis should purchases be made.

The flesh of Fish contains little phosphoric acid, and, like the flesh of other animals, is rich in nitrogen, analysing 15 to 16 per cent. Fish bone is rich in Phosphates, containing about 50 per cent., and at the same time, about 4 per cent. Nitrogen. But the bone is not dry and remains enshrouded with moisture and oil, whilst the flesh around it is decaying and for some time after. With bone, the decomposition, if slow, is regular, the Nitrogen and Phosphoric Acid being placed at the same time at the disposition of the plant. In the case of Fish the flesh is more likely to putrefy first and supply Nitrogen, the bone only later, supplying both Phosphoric Acid and Nitrogen. It is an incomplete manure, for there is practically no potash contained in it. It is never a quick acting manure : its action is gradual and safe.

A disadvantage is found when the fish is oily, and certain harvests like sugar are not benefited when the manure, as is often the case, contains much salt. Sand is often mixed with it, and an analysis should always be demanded. Good fish manure should contain 4 to 10 per cent. Nitrogen and 3 to 8 per cent. Phosphoric Acid.

Far inland the price rises considerably and the purchaser should calculate what he pays per unit of Phosphoric Acid and Nitrogen to find out if it is cheaper or dearer than other manures.

The value of Superphosphates or substances containing phosphoric acid combined with lime, treated with Sulphuric Acid, depends upon the amount of Phosphoric Acid they contain which is soluble in water, or, as it is termed in chemical works, monobasic phosphate of lime. It matters little from what source the Superphosphate is obtained. Double superphosphates are phosphates treated with phosphoric acid instead of sulphuric acid and contain 40 per cent. more phosphoric acid soluble in water. As, in India, a great many people object to the use of bone meal (which is a tri-basic phosphate of lime and contains phosphoric acid not so easily soluble in water as superphosphate), no caste scruples need prevent the use of coprolites.

These should be ground exceedingly fine to help decomposition and will be found very useful in conjunction with potash and a little nitrogen, where root crops, grasses, and leguminosæ are grown, and for all cereal crops with a sufficiency of potash and a fairly good dressing with a nitrogen fertilizer. The nitrogen builds leaf and stem, the potash acts as a carrier of nitrogen and strengthens the stem whilst helping the formation of carbo-hydrates (sugar, starch, gum, etc.) and the phosphoric acid is found principally in the grain, which it increases to a wonderful extent. Care, however, should be taken that the superphosphates are perfectly dry, and they should be used only on soils that contain much lime, or the land is likely to suffer considerably by the binding up of the little lime present with the sulphuric acid, and, though a few harvests may show a wonderful increase, a total failure is likely to follow shortly after.

Land kept under pasture and grazed with farm stock for a series of years becomes steadily poorer. The increase in the animals means an addition to their systems, especially in bone which contains much phosphoric acid, and this is all taken from the soil and requires to be restored. Even in the production of milk a deal of phosphoric acid is required. To restore what is taken away from the soil with the grass upon which the animals feed, phosphoric acid is often supplied by means of superphosphate and generally with decided success.

In two 10-acre fiields of the same quality, the one unmanured, the other treated with 5 cwt. superphosphate per acre, the former yielded 10 cwt. of hay, the latter 19 cwt. of hay per acre. It is used for all manner of crops in Europe and may be tried with advantage in India, often aiding the early maturity of crops, and reducing the period of growth of potatoes, in some cases six or eight weeks, according to Samuel Fraser, in his work on the potato.

From sugar experiments in Java we find the following returns :—

	Weight of cane in lbs.	Sugar obtained in lbs.
Unmanured plot	41,082	5,037
Earthnut cakes 1,180 lbs. and 315 lb. Sulphate of potash	110,103	11,097
By the addition to the above of 393 lbs. superphosphate	114,038	12,041

and at Dinoy, East Java

	Cane lb.	Sugar lb.
Cane without superphosphate	67,307	7,429
With superphosphates in the manure.	89,353	9,409

About 2,000,000 tons of superphosphate are used annually.

Instead of superphosphates, especially where lime is needed, Basic Slag is often recommended. This was a substance found in the furnaces in the process of steel manufacture. Iron contains phosphoric acid, which, in steel, is harmful. It is certainly a good thing in the wrong place. When the iron is in a molten state in the crucible a large amount of lime is added and a strong blast of air is driven through it till it is raised to a white heat. The phosphorous contained in the iron is thereby oxidised and combines with the lime. The silicate in the iron acts similarly. Both float on the surface of the molten metal and the slag is poured away, leaving the metal free from phosphorous, and the Slag rich in phosphate and silicate of lime. The great hard iron-like stuff was for a long time thrown away on the dust heap, till a chemist proved that good money, in the shape of a useful fertilizer, was wasted.

Though not soluble in water like superphosphate, it dissolves readily in the soil, provided it is finely ground. At first the effects of superphosphate are more decidedly seen in the crop than those produced by Basic Slag, but about the time of the harvest not much difference appears. Superphosphate is very useful when a crop is to be helped rapidly, and, among phosphatic manures, is similar in its effects to Nitrate of Soda among Nitrogenous fertilizers. But it is acid and cannot be used with advantage on all soils, and is harmful where lime is deficient. Basic Slag, on the other hand, can be used on any soil, and is specially beneficial to such as are poor in Lime. It is a tetracalcium phosphate and is written in Chemical terms $Ca_4P_2O_9$.

It contains :—		Average	
Phosphoric acid	...	17·25	per cent.
Lime	...	48·29	,,
Iron oxides	...	9·22	,,
Silicic acid	...	7·91	,,
Sulphur	...	0·49	,,

Owing to its contents in Sulphide of lime, which sometimes amounts to 2 per cent. and more and is poisonous to plants, it should be spread some weeks before sowing time. Both the quantity of phosphoric acid soluble in citric acid and the fineness of the slag in order that it may be effective, should be guaranteed. It does not work merely as a phosphatic manure, but is helpful in opening out the soil on account of its contents in lime and its power of freeing the potash of the soil for the benefit of the crop. In using it with potash salts, it should be spread a day or two previously, or, owing to the moisture in the salts, it is likely to clump into pieces resembling cement. A Precipitate is also formed from Basic Slag, and as it contains from 30 to 35 per cent. phosphoric acid, its action is as quick almost as superphosphates.

The table below giving the results of experiments at Bremen, on grass meadow at Hellweger Moor, shows the great increase in yield by the use of Basic Slag. It will be noticed that the addition of Kainit not only increased the outturn, but considerably lowered the percentage of sour grasses and rushes and weeds.

MANURES PER ACRE.	Yield per acre (green).	Percentage Composition of Herbage.						
		Clover and other leguminous plants.	Useful Grasses. 1st Quality.	Useful Grasses. 2nd Quality.	Useful Grasses. 3rd Quality.	Sour grasses and rushes.	Weeds.	Moss.
None ..	44¼ cwt.	5·28	0·11	51·87	5·84	30·06	3·27	3·57
Kainit, 9½ cwt. ..	35¾ ,,	5·25	0·78	50·47	9·70	26·84	4·72	2·24
Basic Slag, 4¾ cwt. ..	54½ ,,	5·91	1·95	32·98	8·00	32·24	14·48	4·07
Basic Slag, 4¾ cwt. } Kainit, 4¾ cwt. } ..	165 ,,	33·47	2·76	22·74	9·99	19·98	5·95	5·11
Basic Slag, 4¾ cwt. } Kainit, 9½ cwt. } ..	215½ ,,	35·63	9·97	20·01	7·56	14·27	7·29	5·27

There is scarcely an artificial fertilizer that has so rapidly won the hearts of farmers as Basic Slag. It was in Germany that its value was first understood, but immense quantities are now put upon the market.

In 1882 field experiments were started.

„ 1883	...	5,000 tons were sold.
„ 1885	...	150,000 „ „
„ 1900	...	1,760,000 „ „
„ 1906	...	2,383,000 „ „

Germany alone produced 1,500,000 tons in 1906, and of this amount used no less than 1,300,000 tons.

Basic Superphosphate is prepared by adding slaked lime to ordinary superphosphate till the mixture is no longer acid.

It is very useful for land that does not contain a sufficiency of lime or has too much vegetable matter. It contains the properties of superphosphate and basic slag and is a manure of great value where the circumstances require its application in place of superphosphate, such as on those tea and coffee plantations poor in lime.

As phosphoric acid is often advertised by manure merchants in terms of phosphate of lime it is advisable to divide the amount thus given by 2·18 to ascertain the quantity of phosphoric acid in the fertilizer. A guarantee is generally demanded of the amount of phosphoric acid soluble in water and the amount soluble in citric acid. Added to this, with basic slag the standard of fineness is generally placed at 80 per cent. passing through a sieve containing 10,000 meshes to the square inch.

A principle long established is followed when, to obtain a cereal crop of 10 cwts., 30 Kg. of nitrogen and 15 Kg. of phosphoric acid are added to the soil.

Wagner asks:—How much Nitrate of Soda and Basic Slag should be used as a manure to obtain an increase of harvest of 10 per cent. of corn? and he replies as follows:—"If the plants are to assimilate 30 Kg. it is sufficient to supply half as much again, viz., 45 Kg. or the 90 lbs. contained in 6 cwt. of Nitrate of Soda. This is in fact sufficient to produce an average of from 20 to 24 cwt. with proportionate straw. But will this hold good with phosphoric acid? and the plant be able with a manure of 3 cwt. of 15 per cent. Basic Slag, to take up 15 Kg. of Phosphoric Acid, and with this produce an increase of 20 to 24 cwt. of corn? There is scarcely a farmer who will accept this, for, in fact, it would require at least 16 cwt. of Basic Slag to effect it, or eight times the phosphoric acid necessary for the crop. It is on this account that no peasant will be such a fool as to believe those who say harm will follow from using too much phosphoric acid in a manure, since seven and eight times the amount necessary for the increase in the harvest is given to soils wanting in phosphoric acid." An apparent superfluity is necessary to satisfy plant and soil, and that such abundance is not superfluous Dr. Wagner has clearly shown. In fact an abundance of phosphoric acid is not lost, but shows results in succeeding crops, and a provision of it in the soil can always be recommended.

Potash is made from the ashes of plants, but not much is procurable in this way and large amounts of ordinary ashes must be carted to the fields to obtain an indefinite return of potash. We know that without potash no plant can grow. For a long time though farmers used ashes they were not aware of the fact that the beneficial effects derived from them were due to the carbonates of potash and lime contained in them. But since the discovery of the potash mines in Germany a very small quantity of potash is found as useful as cart-loads of ashes which are not easy to obtain and are costly to remove to the fields. Digging for common salt, immense quantities of salts were obtained that were not fit for human consumption and were consigned to the rubbish heap, till chemists showed that money was being thrown away; for the rubbish heap contained what, chemically treated, would make an excellent and very necessary fertilizer. The result was that the owners of the mines did not bother any further about common salt, and did an immense trade with Europe and America in the various potash salts they produced. The absolute necessity for using these is apparent. Johnstone in his "Elements of Agricultural Chemistry" says: "As farm-yard manure restores only a portion of the abstracted potash, it would seem reasonable that artificial manures should make up the deficit." In Stephen's "Book of the Farm" it is said, and science and practice both prove the statement only too true, that, "where potash is deficient, the gain in produce obtained by a small application of potash, at a cost of a few shillings per acre, is often remarkable." F. H. Storer, Professor of Agricultural Chemistry, writes in his "Agriculture in some of its relations with Chemistry:"—"Potassium is absolutely necessary for the growth of plants. Indeed there must be a tolerably large supply of the compounds of this element within reach in order that the plant may prosper. Most soils appear to benefit by the application of potash. Profs. Wagner and Maercker have shown, by numerous experiments, that not only sandy and moor lands are improved by potash, but even good deep loams yield better harvests by its application, and Messrs. Lawes and Gilbert proved that, without the application of potash salts, the nitrogen of stable manure as also the nitrogen economy of the soil, suffer permanent and considerable losses through the formation of free volatile ammonia. Potash is also of the greatest importance as the carrier of nitrogen. In the "Assimilation of the Elements of Nutrition by Plants during Different Periods of their Growth" by Drs. Wilfarth, Wimmer and Roemer, it is clearly shown that the less potash is placed at the disposal of the plant the more nitrogen taken up by the plant remains unassimilated, to be finally excreted by the roots."

Germany uses immense quantities of Potash annually and America is fast following suit. The Scotch are known to be excellent farmers who "manure with brains," and do not throw away any money unnecessarily. If the cute Yankee and the cautious Scotchman find Potash pay, Indians need not be timid about its use. The chief salts obtained from the German mines, that practically supply the world with Potash, are :—Sulphate of Potash, Muriate of Potash, and Kainit. The last contains a very great quantity of Chloride of Sodium or common salt, and is exceedingly useful for coconut plantations and grass farms. It has also proved very efficacious with cereals when not more than 3 cwt. per acre was employed. Muriate contains from 7 to 20 per cent. of common salt, but a very large amount, nearly 56 per cent. of potash. Except with sugar crops and tobacco and such plants as suffer if chloride of sodium or common salt is given them, it is perhaps the chief form of Potash supplied to plants, though very large quantities of Sulphate of potash are also employed.

Sulphate of Potash containing about 52 per cent. potash may be used for any crop, though Professor Schneidewind recommends Kainit as the best potassic manure for cereals. Numberless practical experiments have proved its utility in all parts of the world. Of these one only is selected to give an idea of the benefit to be obtained from its use.

E. Meyer reports the following from Stallberg :—

		Bushels.	lbs.
1.	Plot—Unmanured—Harvest in Oats	19	4
2.	,, 160 lb. Nitrate of Soda plus 640 lb. Basic Slag	36	20
3.	,, the above plus 640 lb. Kainit	53	20

Besides its manurial value, Kainit, like Nitrate of Soda, possesses well recognised insecticidal properties, and a secondary effect is the increase in the capillary action of the soils, whereby water is drawn to the surface, thus rendering soils more resistant to drought.

A great number of examples could be given of the profits derived from manuring with Muriate of Potash. One, perhaps, will suffice. In the "Manuring of Oats" as reported in the Strathaven Farmers' Club, we find the following :—

"Mr. Jas. Lawrie, who won first prize, has light sharp soil, and sowed 6 bushels to the acre on 29th April, and harvested on 27th August. He applied a dressing of 2 cwts. superphosphate, 1 cwt. sulphate of ammonia, and 2 cwts. Muriate of Potash. This grew 3,280 lbs. grain per acre, and 52 cwts. 3 qrs. 12 lbs. of straw and chaff. His other plot, manured in the same way, but without the Muriate of Potash, gave 2,320 lbs. of grain, and 44 cwts. 1 qr. 4 lbs. of straw and chaff.

For general purposes it would be more suitable to apply rather less potash, either 3 cwts. kainit per acre or 1 cwt. muriate of potash being a large enough dressing for the oat crop on most soils. But Mr. Lawrie's larger application sufficiently justified itself in this case, as, for 2 cwts. muriate of potash he got an increase of no less than 24 bushels grain and 8½ cwts. straw."

On soils sufficiently rich in lime the Muriate of Potash specially favours the growth of *wood and leaf*, and the production of *large fruits*, though rather later in the season. Sulphate of Potash is to be preferred when an early harvest is an especial desideratum.

The report on the competition conducted by the Ochiltree Agricultural Discussion Society for the prizes offered by the Stassfurt Potash Syndicate for the best crop of oats grown with the aid of potash manures has been issued by Mr. Wm. Sloan and Principal Wright, who say:—"The first prize was awarded to Mr. Robert Bryan, Orchardton, and the second prize to Mr. Wm. Wallace, The Hill. The details of the weight of the crops grown on these farms and on those of the other competitors are appended. The object for which the competition was organized was to illustrate the effect produced by potash manures on the oat crop and on the succeeding hay crop when applied in a proper and skilful manner, and in accordance with the methods of manuring known to be suitable for these crops. It was accordingly stipulated that the potash manures were to be applied to the oat crop along with the nitrogenous and phosphatic manures, in order to allow a comparison with the plots in which the latter manures were applied without potash. The results obtained on the Farm of Mr. Bryan, Orchardton, to whom the first prize has been awarded were equally notable. On this farm 2 cwts. sulphate of potash (92 per cent. purity) added to a suitable dressing of dissolved bones and sulphate of ammonia gave the remarkable increase of 37 bushels (of 40 lbs. each) dressed grain, 40 lbs. light grain, and 23 cwts. straw. On the farm to which the second prize has been awarded, that of Mr. Wallace, The Hill, the effect produced by the potash manure was also very considerable, but it was still greater on the farm of Mr. Wills, Braehead, where 1 cwt. sulphate of potash applied with other manures gave the very profitable increase of 15 bushels (of 40 lbs.) dressed grain, 60 lbs. light grain, and 15 cwts. straw. Attention may be drawn to the combination of manures used by Mr. Wills as a very suitable one for general application to the oat crop. It consisted per acre of 1 cwt. sulphate of potash (80 per cent.) ; 2 cwts. superphosphate (35 per cent.) ; 1 cwt. sulphate of ammonia.

AVERAGE ANALYSES OF THE PRINCIPAL STASSFURT SALTS.

Name of Salts.	Sulphate of Potash. K_2SO_4	Muriate of Potash KCl	Sulphate of Magnesia $MgSO_4$	Chloride of Magnesia $MgCl_2$	Chloride of Sodium NaCl	Sulphate of Lime $CaSO_4$	Substance insoluble in water.	Water.	Pure Potash K_2O. Average.	Pure Potash K_2O. Guaranteed minimum.
A. Crude Salts (Natural Product):—										
Kainit ..	21 3	2·0	14·5	12·4	34·6	1·7	0·8	12·7	12·8	12·4
B. Concentrated Salts (Manufactured Products):—										
a. Sulphates, nearly free from Chloride.										
1. Sulphate of Potash 96 per cent.	97.2	0·3	0·7	0·4	0·2	0·3	0·2	0·7	52·7	51·8
90 ,,	90.6	1·6	2·7	1·0	1·2	0·4	0·3	2·2	49·9	48·6
2. Sulphate of Potash-Magnesia. ..	50.4	..	34·0	..	2·5	0·9	0·6	11·6	27·2	25·9
b. Salts containing Chloride										
3. Muriate of Potash 90 95 p c.	..	91·7	0·2	0·2	7·1	..	0·2	0·6	57·9	56·8
80/85 ,,	..	83·5	0·4	0·3	14·5	..	0·2	1·1	52·7	50·5
70/75 ,,	1·7	72·5	0·8	0·6	21·2	0·2	0·5	2·5	46·7	44·1

Guaranteed analyses of potash salts should be accepted only where the terms are given in Potash. It sometimes happens that it is advertised in terms of Sulphate or Muriate of Potash. In such cases to translate the sulphate of potash into terms of Potash divide the amount stated by 1·85, and potash stated in terms of Muriate of Potash by 1·58.

There are many studious farmers who consider potash unnecessary for their clay soils, which chemically analysed, show large supplies of potash. Professor Wagner, of Darmstadt, speaks very plainly on this point as the result of practical experiments. He says :—"On different soils potash is available in different degrees, and such as are poorest in potash are deprived soonest of the little they have, and are consequently soonest exhausted. The result is that potash manures make a good return in sandy districts for the large amount of potash supplied them. In heavy soils rich in potash the potash is dissolved much more slowly, and it is on this account that one should not depend upon the chemical analyses of such land, for, notwithstanding the high percentage shown, the crops do not give the best returns because of an insufficiency of available potash." Wagner's experiments showed the following results. The first were made on loam, loamy sand, and sandy soils, and red clover, potatoes, rape, and barley were grown. Of 100 parts of potash found in the soil by analyses the plants removed 4·3 parts from the loam, 7·4 from the loamy sand, and 7·4 from the sandy soil. In the second experiment the same soils were used for oats, pease, wheat, rye and barley. Of 100 parts of potash in the soil these plants removed 4·5 parts from the loam, 8·6 parts from the loamy sand, and 10·6 from the sandy soil. The third experiment was tried on six different soils, in which for three successive years Italian rye grass was raised. This crop removed of every 100 parts contained in the soil :—

Soil.	1st Year. Percentage of potash removed.	2nd Year. Percentage of potash removed.	3rd Year. Percentage of potash removed.	Total. Percentage of potash removed.
1. Sandy Soil (rich in humus) ..	48·7	7.0	10·3	66·0
2. Sandy ..	44·2	6·3	4·7	55·2
3. Sandy Loam ..	42·9	10·5	3·6	57 0
4. Loam ..	24·2	4·6	4·1	32 9
5. Sandy Loam ..	13·1	2·7	1·6	17·4
6. Loam ..	11·5	4·0	2·2	18·7

Of pure Potash used in Agriculture the figures are

for 1880 ... 29,127 tons

1900 ... 255,722 „

1906 ... 452,804 „

Of course the figures are ever so much greater for the manures that contain varying percentages of potash and those of 1906 go well beyond a million tons.

Dr. Maas, of Muenster, writing of "The Action of Common Salt on Cultivated Plants," says :—"The elements, chlorine and sodium which, combined in certain proportions, form common salt, were for a long time considered absolutely necessary for the normal growth of plants, and if such is not the opinion of agriculturists of the present day, science is yet far from clear as to the part these two chemicals play in plant physiology. The question is important for the agriculturist, for a great deal of common salt is added to the soil when potash salts, especially the raw potash salts, are used in quantities as manures. Practical experience teaches us that chlorine and soda at least help to a considerable degree the growth of many plants. Buckwheat, for example, grows better when chlorine is placed at its disposal. Other plants show in their ashes a preponderating amount of the combination of the two elements, which even regulate the outward appearance of the so-called 'salt plants'. There are also many pastures and meadows, annually submerged by salt sea water, which give fair returns, a proof that common salt suits them. Wagner found, from various experiments, that many of our cultivated plants of the class to which the turnip belongs cannot give the best harvests unless soda is added to the soil. A special physiological action is brought about by soda on the plant during the early stages of its growth, which cannot be accomplished by other chemicals nearly allied to soda. Schneidewind believes he can trace this good effect to the ease with which soda is assimilated perhaps, or partly to the rapidity with which it carries the nitrate and phosphoric acid through the plant. It may be of interest to mention an experiment carried on for ten years by Privy Councillor Wohltmann on the grounds of the Agricultural Academy of Poppelsdorf, on heavy clay soil. The test was made on the most important cultivated plants with increasing doses of salts, till the application reached 500 kg. per morgen. Manuring was not carried out every year: between two manured plots one always remained unmanured as a check plot. Though in other places common salt was used with benefit for barley, in this case such was not the case, nor did it benefit wheat, pease, or beans. Even buckwheat did not respond, contrary to expectation: when so heavy a manuring as 500 kg. was given per morgen, the harvest was an almost total failure. Rye suffered least, the corn was less: but the wheat increased. Rye, however is a crop which when grown on good soil, responds least to manure. Potatoes are well known to feel the effects of chlorides ; the tubers were less as also the contents in starch. Still if chloride is placed at the disposition of the potato it assimilates it greedily, and it finds its way into the leaves. But the tuber cannot bear the soda at all. With beet and still more in the case of turnips manured with 500 kg. per morgen the increase was great, even reaching 35 per cent. The increase was not greatest with the heaviest application of manure. The sugar contents of the beet did not suffer. The turnip takes soda with avidity and uses it and thus explains its preference for Chilisaltpetre over Sulphate of Ammonia. It grows wild near the sea where it receives its supply. But even to such plants, on clay soils, we advise a manuring not with salt but with kainit which contains salt also.

Regarding the purchase and use of well-balanced fertilizers the following words of Principal Wright, of the West of Scotland Agricultural College, in addressing the Kircudbright farmers, under the auspices of the Stewartry County Council on "Some Hints about Buying Manures," require serious attention :—

Numerous experiments carried out in England during the past ten years, as well as those carried out in the West of Scotland, had all shown that in ordinary farm conditions the manure for each crop should supply the whole of the three ingredients: Nitrogen, Phosphoric acid, and Potash. It was probably the cheapest method for farmers, who had the requisite skill and knowledge, to buy these ingredients in separate manures, and to mix them for themselves, or to apply them to the land separately, one after the other ; but, on the other hand there were practical difficulties connected with the proper mixing of manures on farms, which had caused many farmers to prefer buying manures already compounded for them by manure merchants, and more than half of the manures used in the country consisted of these specially prepared mixtures. These mixtures sold by merchants had several advantages to compensate for the drawbacks. First of all, the mixing of the ingredients done in the manure works was much more thorough and efficacious than could be done on the farm, because farmers had not the requisite machinery. For the same reason they could be more cheaply mixed in the manure works, and they could be sent out in a finer state of division. This was of great importance, because on the thorough mixing of the ingredients, on the freedom from lumps, and on the dryness of the manure, depend its equal distribution over the soil, and the amount of effect it would produce on the crops, and it was certainly better to pay a higher price for manure in thoroughly good condition, then it was to buy a less effective manure at a cheaper rate. Another great advantage in mixed manures supplied was that they were prepared for the requirement of each particular crop. Manure merchants deserved very great credit for this. They seemed to have escaped altogether the idea which prevailed so widely and which was essentially erroneous, that manure required to be varied in a great degree, on account of the nature of the soil. As a matter of fact, the manure that would grow a good crop of turnips in one part of the country, would also grow a good crop in another, and while within narrow limits some variation had to be made to suit the nature of the soils, it was essentially and mainly true that manures ought to be adapted to suit the requirements of the particular crops and not the soils."

Professor Wagner, of Darmstadt, speaking of the use of artificial fertilizers, lays down certain rules gathered from practical experience. We cannot by the use of farm-yard manures alone obtain from our fields the greatest profit gross or net. We must consequently use with it such artificial manures as can be purchased. An incomplete manure with Nitrogen or Phosphoric acid, and Potash will never give the best results. We must make use of all the plant food-stuffs in the right proportion. Each acre and each crop requires a special fertilizing and it behoves the farmer to learn this by experience and to prove it.

It is not advisable to use Kainit and Chilisaltpetre (Nitrate of Soda) in large quantities on heavy clay soils, because these salts harden the land, crust it and render it impervious to water. It is true that repeated liming can lessen the ill-effects, but it will never completely remove them.

On heavy land only Sulphate of Ammonia should be used as a nitrogenous manure, and, when Potash is required, a concentrated potash salt such as 38 per cent. Potash fertilizer should be employed. Similarly Basic Slag is better for sandy soils, superphosphate for those of heavier texture.

Certain soils act better on one quick-acting manure than on another. The beet-root, for instance, is, better treated with Saltpetre, the potato with Sulphate of Ammonia.

It is the same with potash salts. Certain plants thrive better with Kainit, that contains besides potash, common salt and salts of magnesium, which would certainly not be judicious to add to the soil where sugar is to be raised.

Though sulphur in its free state or as sulphites is harmful in plant-life, it is very useful in the form of salts such as sulphate of ammonia, potash, magnesia, and lime. The last-mentioned, usually termed gypsum, when ground fine, is considered a preservative of the nitrogen in farm-yard manure. When mixed with the manure heap it decomposes the carbonate of ammonia forming sulphate of ammonia and sulphate of lime, and thus preventing ammonia escaping as a gas. It acts upon the potash of the soil rendering it available as plant food and thus, like lime, acts as a secondary manure. There it will also serve to render available plant foods in the sub-soil and benefit especially deep-rooted plants. It helps also as a good regulator of moisture. On alkaline lands termed in India reh, kullur, or soudu, containing a heavy percentage of carbonate of soda, its efficacy appears to arise from the breaking up of the carbonate of soda into free carbonic acid which escapes into the air, and soda which is not only harmless, but at times takes the place, to a certain extent, of the potash that may be wanting. Used in conjunction with a complete manure, crops will be obtained in such places where formerly even grass refused to grow. Experiments in the North Arcot District with bisulphate of potash neutralised by lime have proved exceedingly beneficial in field experiments on *reh* soils, the harvest rivalling those from the best paddy fields.

In order to find the unit value of the different ingredients forming a fertilizer we must study the valuation of manures. This does not refer to the value of manures in increasing the crops. Some may be excellent when used alone, even when not complete, if the soil be well provided with the other necessary plant-food constituents, or useless if these are not present, others may be complete and well-balanced, or more suitable for certain crops or soils without being so costly. By the word valuation is meant here the price on the market.

To make a comparison we must know for what principal food or foods the manure in question is sold, and compare the prices of other manures bought for this special food.

We therefore select a unit of price for 1 per cent. of the particular food constituent in a ton of the fertilizer.

Sulphate of Ammonia, for instance costs, say Rs.180 per ton, whilst Nitrate of Soda is valued at, say Rs. 172. Both are quick-acting manures. The former contains 20 per cent of Nitrogen, the latter 15·5 per cent.

To compare prices, we find the value of the unit of Nitrogen, thus:—20 units in Sulphate of Ammonia cost Rs. 180, or Rs. 9 per unit. In Nitrate of Soda 15·5 units would cost Rs. 170-8, one unit costs Rs. 11. The extra Rs. 2 per unit may be repaid by its use when Sulphate of Ammonia would not be so efficient. With these, other nitrogenous manures can be compared.

Say an oil cake well-ground and ready for use in the fields, cost Rs. 65 per ton. It contains 5·5 per cent Nitrogen. The unit value will then be Rs. 11-13; but as this is a slow acting manure compared with the two mentioned above, it may be of less value for any particular crop, and consequently may be very much dearer, in fact, than the others; or, it may be just what is wanted, a good but moderately quick acting nitrogenous fertlizer, and then its higher comparative value per unit may be worth paying for, as little will be washed into the drainage. There is generally a small amount of phosphoric acid and potash in oil cakes, and, though, this is not usually allowed for, the value should be calculated, after the manner shown below.

A superphosphate, containing 32 per cent. of phosphate soluble in water, costs say Rs. 60 per ton. Being very soluble it can be taken as a standard for arriving at unit prices, thus :— 32 units cost Rs. 60 ; the price of one unit will be Re. 1-14.

Basic Slag contains 30 per cent Phosphate, but it is soluble in citric acid, not in water. The price in the market is, say Rs. 40. The unit value will consequently be Re. 1-5-9. From actual results obtained on the field we can judge which will be the cheaper manure to use, the superphosphate at Re. 1-14 per unit, or the Basic *Slag at Re. 1-5-9 per unit.*

Similarly, Potash manures can be compared. Muriate of Potash containing 50 per cent of Potash at Rs. 150 per ton means Rs. 3 per unit of potash, whilst Kainit, containing only 12½ per cent at Rs. 50 per ton would mean Rs. 4 per unit. Of course, for manuring coconuts, the common salt it contains would be of value, and this might be compared with the market value of the article on the spot, and thus lessen considerably the cost per unit of the potash for which it is sold.

So taking an average unit value of Nitrogen as Rs. 10, that of soluble Phosphate at Re. 1-10 and that of potash at Rs. 3, we can at once find what should be the value of a mixed manure. Suppose we have bone meal.

The Nitrogen in it is 4 per cent. for example : the Phosphoric acid 23 per cent.

Were we to say 4 units of Nitrogen at Rs. 10=Rs. 40 and 23 units of Phosphoric acid at Re. 1-10=Rs. 37-6. total Rs. 77-6, the calculation would be very misleading. Bone does not dissolve rapidly and place its nitrogen and phosphoric acid quickly at the disposal of plants. The market value is, say Rs. 60. To make our comparison of unit values, we must compare first the value of the phosphoric acid for which it is principally sold. This would probably be placed on a level with Algerian or rock phosphate containing 60 per cent. and valued at Rs. 43 per ton, or 12 annas per unit, and the bone would be valued at 23 × 12 annas for its contents in phosphates, viz., Rs. 17-4. The balance Rs. 42-12 would be the price of the 4 units of Nitrogen, i.e., Rs. 10-11 per unit, rather heavy if the Nitrogen is required to act on the plant in a short time.

So if a manure were guaranteed to contain

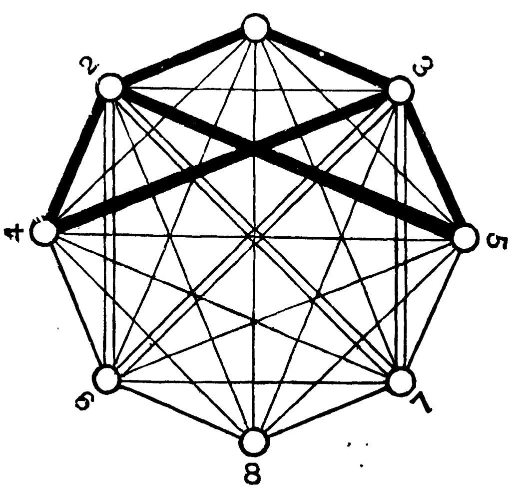
Nitrogen	5	per cent.
Soluble Phosphate ...	15	,, ,,
Insoluble Phosphate ...	5	,, ,,
Potash ...	10	,, ,,

the value would read per ton :—

Nitrogen ...	5	units at	Rs 10- 0	=Rs. 50- 0
Soluble Phosphate ...	15	,, @	Rs 1-10	=Rs. 24- 6
Insoluble Phosphate ...	5	,, @	Rs 0-12	=Rs. 3-12
Potash ...	10	,, @	Rs 3- 0	=Rs. 30- 0
				Rs. 108- 2

It must be remembered that in applying various manures to the soil and in mixing the same before application, certain chemical changes take place. Some of these may result in the loss of a valuable ingredient, or a soluble manure may become very difficult to dissolve. Thus lime manure should not be mixed with farm-yard manure, guano, sulphate of ammonia or other nitrogenous fertilizers. Again mechanical changes may occur. Kainit and Potash salts mixed with some artificial fertilizers, if not at once spread over the land, will produce a hard, solid mass, difficult to break up and dissolve, and lime added to superphosphate renders it far less soluble.

Dr. Geehens, a German Agricultural Scientist, drew up a simple chart showing what artificials may be mixed. We reproduce the same below :



1. Superphosphate.
2. Lime.
3. Basic Slag or Thomas Phosphate.
4. Ammonium Sulphate.
5. Farm-yard Manure and Guano.
6. Potash Salts.
7. Kainit.
8. Chili Saltpetre or Sodium Nitrate.

Those manures which are joined by thick lines must *never* be mixed *before* using; those by the double line, only immediately before spreading; those by the single line may be mixed together at any time.

When we see the wonderful effects of intensive farming in Europe we are astounded at the little done in this country to improve the crops. Yet an expert writing on the subject said:—"The average cereal crop yield all over India has been estimated at about 11 bushels per acre as against 30 bushels per acre—all cereals included—in England, and that millions of acres in India average four bushels or less, while even the addition of one bushel per acre would pay the whole revenue and would feed the increment of population for a whole decade."

The great Liebig once wrote:—"I shall be happy if I succeed in attracting the attention of men of science to a subject which so well merits to engage their talents and energies. Perfect agriculture is the true foundation of trade and industry—it is the foundation of the riches of States."

This is true Swadeshi. Germany knows the meaning of Swadeshi and her scientists came to her aid in the right manner. In 1876 the beet production was 360,000 tons. In 1896, it had risen to 1,620,000. The average product in 1876 was less than 2,000 lbs. of sugar for every 10 tons; in 1896 the production was 3,000 lbs. Similarly in the matter of manuring cereals Germany has led the way and has been followed by other countries. Is it not time that India endeavoured to produce that one extra bushel capable of paying the country's extra taxes and for providing for the enhanced population in the next decade? What dreams of wealth would be before young India if only the 30 bushels of cereals could be obtained here. If the people cannot find " muck, muck, and plenty of it, " they can always supply its place by "fertilizers, fertilizers, and plenty of them."

There are a few points that sometimes puzzle the farmer. He may find his crops rise splendidly, and develope leaf and stem year after year, but produce little corn. In this it is evident that though the nitrogen and potash are present in sufficient quantity the soil needs phosphoric acid.

A light green or yellowish colour of the leaves, reddening towards the extremity, points to an insufficiency of nitrogen.

As a rule soils that remain moist are seldom in want of nitrogen— the drier the soil, the more, as a rule, is there a need of nitrogenous fertilizers, for the soil is generally poor in humus.

In using nitrogenous fertilizers note should be taken of the moisture of the soil and its mechanical texture. The amount considered sufficient in fairly dry seasons becomes too much in wet seasons, and the plants assimilating more of it run into leaf instead of producing grain, because with the increase of moisture more nitrogen is placed at the disposition of plants. Clayey soils require more phosphoric acid in the fertilizers because the soil is generally more moist, while with sandy soils the opposite treatment is to be carried out.

When the plant is flowering and about to fruit it builds the necessary substances from the materials already taken up from the soil and contained within its own body. For the development of leaves nitrogen is necessary, and a large supply before the fruiting season produces a plentiful store within the plant of the necessary material for the fruit. But overdoses of nitrogen often cause the lodging or falling over of plants due to the weight of the leaves, which the stem cannot bear upright, and result in a diminution of fruit. But even when lodging does not take place, overdoses of nitrogen and too much water delay the plants in maturing, *and in many cases the harvest does not keep.* This appears to be the case particularly in the potato crop in India.

Phosphoric acid increases fruiting and hastens maturity.

Potash helps the general progress of the plant and serves as a carrier of Nitrogen.

It has long been fixed in the mind of the European planter in India and Ceylon and is fast becoming a dogma among educated landholders of this country that analyses of the soil is absolutely necessary if any improvement is to be thought of in regard to local agriculture and intensive farming.

One of the mistakes to be expected here with the revival of agriculture is an inclination on the part of the educated landholder to rush to a perusal of scientific works on agricultural chemistry. The owner of the land may or may not be conversant with practical farming, but his books speak of the importance of soil analyses, and straightway he sends a sample of his fields to the nearest chemist. There he ascertains his soil is rich, say, in potash, and immediately decides that he can do without a complete manure, and that potash would be an unnecessary and wasteful expenditure. Logical as it appears, the argument is weak, because he assumes as correct that what the chemist finds in the soil is food immediately available for plant-life. An eminent agricultural authority, speaking on the subject, condemned most strongly this reliance placed on the authority of chemical analysis, and the *Colombo Agricultural Magazine*, as for back as March 1902, said: "Such people think it is enough for them to send a sample of soil to a chemist with a note reading: 'Please analyse the accompanying sample and let me know what manure I should apply'. The ignorance displayed by such a bare request is only equalled by the audacity of the reply prescribing the kind of manure to be used."

We must bear in mind that it is nearly impossible to obtain a sample fairly representing, say, a ten-acre plot, and the analysis, at best, merely shows what the soil contains, but cannot tell the farmer whether the plant-food is available i.e., if it lies in the soil in such a state that the plants can make use of it, nor does it assist him to learn how the food can be rendered available. There is abundance of plant-food in many a soil such as *reh*, soudu, or alkaline tracts on which nothing will grow. Here we have to take into consideration not only the physical condition and mechanical texture, but also the deleterious substances in them that destroy plant life. But taking ordinary soils and analysing them, are we helped much on the subject of manuring?

Agricultural chemists have done an immense amount of good to the agriculture of the present day, especially those scientific men in Germany, who dedicate a whole life-time to the closest study of the minutest details referring to plant life. But a further study of this subject has brought home to the student and to the practical man the limits of the science. We have heard a good deal of the plant-foods and of the necessity of having these in the soil. But practical analyses soon proved that even the worst soils often contained in the first few inches of the surface a great deal more of the principal plant-foods than would be necessary for a large number of crops.

This has led to a theory among American agriculturists, that the manure does not act chemically, but merely influences the mechanical texture of the soil, thus regulating the plant climate.

No question arises concerning the value of manuring. It is merely a theory of the manner in which the manure affects the plant and soil, a theory far from proven and in direct opposition to the teaching of all European scientists.

To show the difficulty of deciding what plant-food is available and what is not we have only to take up the report of the Rothamsted Farm, where the land has been cropped since 1839. Though unmanured for 70 years one plot contained 2,500 lb. of Nitrogen. As an ordinary crop takes from an acre between 50 and 100 lb. nitrogen, 20 to 30 lb. of phosphoric acid and 30 to 100 lb. of potash, the land evidently had large stocks of all the plant-foods required. Yet the addition of 18 lb. of Nitrogen in a concentrated fertilizer increased the crop. Evidently, therefore, the Nitrogen in the soil was not sufficiently available to return a full crop, and a very small addition of the requisite plant-food in the manure caused the increase. The same was seen by the addition of phosphatic and potassic manures. Again, the plants themselves do their selection, and one plant can get its supply from a given field while another cannot. Wheat and barley take about the same amount of phosphoric acid from the soil. Yet on an unmanured field at Roathamsted the wheat got its full supply, while the barley could mature only with the addition of a phosphatic manure.

The chemists, in giving us the analyses of soils can, consequently, give us only figures to help a comparison of one soil with another, but cannot tell us how much of the plant-food contained in the acre can be assimilated by the plant.

Samuel Fraser, writing on the potato, says :—"A 300 bushel crop has been found to contain 81 lbs. of phosphoric acid and 79 lbs. of potash. Taking 49 New York soils, *the chemists found that the* surface 8 inches contained *per acre (N.Y. Cornell. Bul.* 130 p., 157) 3,053 lbs. of *nitrogen enough for 38 crops,* 4,219 lbs. phosphoric acid, enough for 137 crops, and 16,317 lbs. of potash enough for 207 crops. No farmer will say that it is possible to grow numberless crops in succession on an acre of land without manure ; but, if we merely draw our deductions from the chemists' analyses, this is the sort of thing that confronts us, viz., that manuring is absolutely unnecessary, and will be for years to come on a very great number of soils. Of course an objection can be raised that the plants do not cover the whole acre in each season, but, allowing for changes of position in the rows, etc., we are still led to the conclusion, by the chemist, that fertilizing is neither necessary nor beneficial. Of this we can merely say, in the words of our school friend Euclid, "It is absurd."

Here science and practical farming do not appear to agree. In such a case it is always advisable to look for a fault in the scientific deductions and place full reliance on long experience. The difficulty to be explained was, if so much plant-food existed in the soil, why did not the plants make use of the provision before them? The answer was simple. The food was not in such a form as to be available for plant life To say what is and what is not available is so difficult that the matter is far from determined yet. The go-a-head American farmers did not care to bother much on this subject. They started from the principle that certain plant-foods were taken from the soil by each crop. Experience taught them that, in course of time, their richest lands had been so reduced as to return poor crops, and the remedy found was manuring. Whether plant-food was still in the soil or not, and how far this might be in an available state were questions perhaps interesting to the scientist but of little importance to the practical farmer. He said each crop took certain amounts of plant-food from the soil and that his crops lessened in consequence, and his hard common sense told him it paid best to supply to the soil substances that would readily dissolve in water and place in the soil the ingredients withdrawn by the harvest. He did this, and science found he was right, and nowadays the science of manuring is reduced, to a great extent, to a mere matter of ascertaining what the crops take out of the soil and replacing these, as a minimum, at the least possible expense, in the proportion in which the plants require them. Experience may teach us that a greater supply of phosphoric acid may be needed for a bumper harvest than the analyst finds in a bumper crop. We follow experience in this and leave the analyst alone, satisfied that there are many things in agriculture that no chemist can as yet explain.

Dr. Leather, delivering a lecture, a few years ago, on some recent investigations in the Chemistry of Agriculture, said :— " There is perhaps no subject which has claimed the attention of the agricultural chemist more than the soil. At the same time it is one of the domains of agriculture about which, if we have learnt much in the past, we have much to learn in the future." Playfair, when editing Liebig's Agricultural Chemistry, expressed surprise that the chemist of that day should be content with the determinations of the amount of silicates and iron and alumina, leaving the potash, phosphoric acid, etc., undetermined. It was a comparatively simple matter for the chemist to free himself from this criticism, and he proceeded to determine the amount of the valuable plant-foods, the lime, potash, phosphoric acid and nitrogen, with very great precision. This told us how much of these ingredients were in the soil. As years passed on, it became evident, valuable as this information was, it was insufficient. The chemist would find what appeared to be only a small proportion of potash or phosphoric acid. whilst if a manure were given to supply the deficiency, it might happen that the crop did not respond to the more liberal treatment in such a measure as one might have expected. Or, conversely, it was found that whilst a few tons of farm manure, or a few hundred pounds of more concentrated artificial manure would have a remarkable effect on a crop, the actual amount of plant-food contained in such manures was far less than the soil itself contained. One fact that appeared very striking was that soils, which either appeared poor from the chemical analyses, or were actually known to be poor agriculturally, contained admittedly very much more plant-food than several, or indeed many crops required. It was known that, at the most, a good crop only required a few pounds, ten, twenty, or thirty, of potash or phosphoric acid, whilst on the other hand soils rarely contained less than one per cent. of either of these plant-foods, usually indeed more than this, and such a proportion amounted to no less than about 4,000 lbs. per acre in the surface soil, to say nothing of the stores which the subsoils were known to contain. It was clear that all this plant-food could not be equally within the reach of the crops, that some portion of it must be in a different state of combination to another, the plant being able to assimilate the one more readily than the other. One commenced to speak therefore of " readily available plant-food " as distinct from that which was not so. Whilst a recognition of such a difference was easy, and the problem to be solved made clear, the method of differentiating between, say the portion of the phosphoric acid which the plant could readily untilize, and that other portion of the same material which it could not, was by no means clear."

To this day it is a most difficult problem to decide how much plant-food in the soil is available for plant life, and it is on this account, we recommend the American system of ascertaining what has been taken from the soil by a crop, and then placing on it, for the next, at least the same amount of nitrogen, phosphoric acid and potash that have been extracted.

There are several knotty questions which the student of intensive culture might well leave aside for the present. Even the British Association could not give an explanation of the deleterious effects of grass upon orchards. The why and the wherefore of many things may be learned later on, provided we reap the benefits from the facts at present. Here we have good farmers all over the country, whose excellent mode of agriculture may be deficient in certain respects either through ignorance of chemistry or their want of means. But they are amongst the best farmers in the world, and it would be better to bring science to our aid in learning the reasons that actuated their forefathers in the methods employed than to deny what generations of practical men have proved to be highly beneficial. If the greatest scientists fear to speak *ex cathedra*, it does not do for beginners to have opinions too pronounced.

A very great advance will have been made if the Kunbi can be persuaded, in the absence of a sufficiency of cattle manure, to use concentrated fertilizers that, far from harming the soil, will enrich the land, while producing bumper crops.

That there are still numberless subjects in agriculture which require the constant attention of the chemist, there is no doubt, and that we have gained much from the scientists' study of plant life is evidenced by the millions saved in the victorious conflict against plant diseases and various enemies of plant life. But science has not so far advanced as to tell us with certainty how much plant food is in the soil in a state available for plant nutriment, and at this stage it is more advisable to endeavour by means of manures, to place in the soil ingredients easily soluble in water, to replace those taken away by the crop, than to trouble ourselves with the very vexed question as to what the soil contains which scientists consider available.

This does not mean that all soil analyses are to be neglected. It is well known that in the absence of lime all the manuring in the world is useless till the necessary minimum is supplied. It is also established as an axiom of agriculture that the crop will respond not to the maximum of one ingredient of plant-food supplied, but to the minimum of any one ingredient the soil may contain. A long as this is remembered and the question of availability is omitted, chemical analyses may often be found useful, sometimes even necessary.

Chemists, applying their science to agriculture amassed a number of facts, which, as individual reports were not of much value, till their study produced the general deductions on which scientific laws could be founded.

Saussure, for instance, analysed the ashes of plants and invariably found that they contained phosphorous, and he rightly judged this essential in plant growth. Boussingault went a step further, and analysed both the crops and the manure supplied. He could account for the carbon obtained from the carbonic acid of the air and the hydrogen and the oxygen from the water, but could not account for the nitrogen. The physical properties of the soil and the air and the water supplied were counted on in studying the harvests obtained from the soil.

Liebig found that the mineral matter contained in the ashes of plants were obtained from the soil and that by the addition of these the plants benefited and bumper harvests could be obtained. But he required a further study of the subject than his 'Laws of Manuring' supplied, and Messrs. Lawes and Gilbert showed the necessity for and the preponderating importance of nitrogen in all crops. Here analysis proved of the very highest value to the Science of Agriculture, which owes a heavy debt of gratitude to Chemistry. But when it is a question of the relation of a manure to a soil and what manures will suit certain soils, a mere analysis is far from sufficient, and the question is finally settled by trials in the field. From these we can learn what manures suit certain crops best on different soils and draw a fairly general rule for the application of fertilizers to the crops.

But its chief value lies in the possibility of comparing soils when after various analyses have been made in a district, their practical agricultural value is ascertained. Thus a sample sent can be placed by the analyst in a relative position as regards fertility, ordinary conditions being otherwise similar. In course of time such analyses give a very good idea of typical soils, and later on these can be classified without much danger of grave error. If, for instance, he finds a fair average sample of soil on which he has to decide, he can say it ranks with poor, medium, or good soils, the value of which for agricultural purposes is known. He can then, with his knowledge of what has been done on other similar soils, suggest certain manures worth trying for crops raised on that class of land. But here the practical part of the business depends not so much on his science as on the practice of the farmers which he has learnt in conjunction with his analyses. His advice regarding manures would be worth very little otherwise.

When dealing with the analyses of fertilizers he can tell if they reach a fixed commercial standard of purity and price, and he can be absolutely certain in his statement—a very important point when so much adulteration can be carried on without the possibility of discovering it by the look or feel of the article. Agricultural analyses are of the greatest importance in such cases. They are also of the greatest value where the purity of oilcakes and other feeding stuffs for cattle must be determined, for the health of the farmer's cattle and their weight and strength depend on their feeding, as also the value of the store of manure.

Certain lands like *reh, soudu,* or alkaline soils bear next to no crop. Here chemical analysis is absolutely necessary to tell us what substances the land contains deleterious to plant life and what necessary plant-food may be missing or deficient. We may then by means of chemistry supply the missing plant-food and by inserting materials likely to form chemical combinations, render the deleterious substances innocuous, if not useful. But the value of soil analysis in other instances has been very much over-rated. In the generality of cases, with ordinary soils, there is little need to have recourse to chemical analysis.

The mechanical texture of the soil, however, is of great importance to the farmer, especially when he writes for advice concerning failure of crops or the fertilizers he may require. Certain manures are not available in certain soils or they may be less effective than others, and a few simple rules to ascertain the mechanical texture of the land, may be of use to our readers.

Soils are generally classified as :—1. Sandy, 2. Sandy loam, 3. Loamy, 4. Clayey Loam and 5. Heavy Clay.

If the soil does not contain too much vegetable matter, dry the few ounces you wish to test, weigh them, break up the earth, pour upon it a pint or two of water, shake it up well and allow it to settle. The sand will sink to the bottom. Then pour away the mixture of clay and water into another vessel, which should not be disturbed till the clay settles at the bottom, when the water should be poured away carefully.

When the sand and the clay are dry they should be weighed exactly. The proportion, compared with the original weight of the soil tested should be noted.

If 10 grains weight of clay is found in 100 grains of the earth it is termed sandy soil.

10—40	Sandy Loam.
40—70	Loam.
70—85	Clayey Loam.
85—95	Heavy Clay.

The last mentioned is a soil very difficult to cultivate. Soils are often designated by the amount of carbonate of lime found in them. Those found containing 5 per cent. are called marls, and if they show more than 20 per cent. of carbonate of lime they are calcareous.

Clay soils are often improved by an addition of sand, and vice versa. Cattle manure invariably helps to loosen clayey soils and to render sandy plots more compact.

In his work on Tropical Agriculture, Semmler gives a fair means of ascertaining, by a rough test, the value of land the farmer may buy, testing it for clay and humus, lime and magnesia, and the moisture-holding power of the soil. He says :—" Whoever wishes to take up a virgin piece of land should be capable of making a soil examination by separating the fine and slimy parts from the coarser particles by means of washing with water. By this process the presence of some of the most important soil constituents and an approximate idea of their quantitive proportions may be ascertained, and thus some fairly reliable conclusion as to the fertility of the soil becomes possible. The materials required are a few wineglasses, a small pestle and mortar, a piece of litmus paper, a small scale, a small bottle of muriatic acid, another of ammonia, another of oxalic acid mixed with water, a fourth of phosphate of ammonia and of soda and some filter paper, all of which may be bought at any chemist's shop.

Suppose it be desired to try if a soil contains sand and clay. Take 50 grammes of the soil (19-43 grains

Troy=1 Gramme) or 33·14 dwt. Grind it well in the mortar, having wetted it first till it is reduced to a soft pasty mass. Now dip a piece of litmus paper into it. If this turns red, there is a proof that it contains humic acid and hence that drainage is required or that lime should be applied. Now pour the liquid into a tall funnel, reduce it largely with water, and carefully wash out the mortar, emptying what remains in it into a funnel. If it then be allowed to stand for a little time, the various constituents will sink to the bottom of the glass according to their specific gravity and their degree of division into particles. The coarse sand sinks first, then the sand, followed by clay, and if humus be present this will form the upper layer. From the depth of the layers a fairly safe conclusion may be arrived at as regards the proportional quantity of each constituent contained in the soil.

To continue the examination stir up the sediment and in a few minutes pour the cloudy liquor into another glass, being careful not to allow the sand, which will have meanwhile again sunk to the bottom, to flow off. The residue must be mixed with water, stirred and, as in the first instance, be poured out. Continue this process, until apparently nothing is left in the first glass but sand. Now dry the sand in filter paper and then weigh it. What it falls short of 50 grammes will be put to the account of fine soil clay and humus.

To examine for lime, weigh off 20 grammes of the dry soil, pour it into a bottle and add 6 times as much water; then add gradually from 6 to 10 grammes of muriatic acid put away for several hours in a warm place. If, when the muriatic acid is added, a distinct buzzing sound is heard, this is a proof that the soil is rich in lime. When the contents of the bottle have become perfectly settled pour them on to filter paper and add the washing of the bottle as well. The yellow liquid is filtered through, which must, of course, be caught in a glass mixed with ammonia until it distinctly smells of it. If brown flakes separate themselves in it, these will be oxyhydrate of iron and hydrate of alumina (with phosphoric acid). The liquid must again be filtered and, in its liquid state, must be mixed with a solution of oxalic acid and water so long as any cloudiness arising from oxalate of lime appears. Note must be taken, if during this process the smell of ammonia disappears: should this happen, the smell must be restored by the addition of more ammonia. The lime content may be ascertained by the quantity of precipitation: but if a more accurate calculation be required, the liquid must be poured on to a dry piece of filter paper which has to be accurately weighed; the *precipitated matter on the paper must then be washed* and dried near the fire. Then both the paper and precipitate are weighed and the gain in weight is taken as the oxalate of lime. By heating it is changed into carbonate of lime.

To test for magnesia a little ammonia is added to the oxalate of lime. Then a little phosphate of ammonia *is dissolved in it and is stirred with a glass rod.* After a short interval, if there is a large percentage of magnesia, a crystalline sediment results, which consists of ammonia phosphated magnesia. If the percentage of magnesia is small there will be little precipitate and only after standing for a long time.

To test the moisture-holding power of the soil, weigh 100 grammes of dry earth, pound it fine in the mortar and empty into a glass, the weight of which, together with its contents must be ascertained. Then pour as much water into the glass as will completely cover the soil, as much as it cannot be expected to completely absorb. In 24 hours the superfluous water must be carefully poured off and the glass again weighed. The additional weight gives the percentage of water which the soil can take up. This power of water absorption reaches, in the cases of clay and humus to 80 and 100 per cent. In the case of gravel and sand it falls to 20 and 25 per cent."

The land thus studied, the next object of the practical agriculturist should be to ascertain what his crops take off the soil per acre and the means to be employed for increasing the harvest. There is a book by Professor Wolff giving the analyses of a great number of plants as also a list by Dr. Lierke of the amounts of plant-foods removed by various crops, but if these be not procurable, recourse should be had to the Department Agriculture to ascertain what quantities of plant-food are taken off the land by average Indian crops. These ingredients should then be added to the soil to the extent at least and in the proportion in which they are removed : for bumper crops larger quantities are required. We may then hope for the extra bushel in cereal crops that will change the raiyat's lot from that of misery verging on starvation to one far more closely resembling that of the prosperous European farmer. Having learnt theoretically the value of manures and a rough chemical test of soils to enable us to consult others about the most economical fertilizers to use with our crops, we must begin from actual practice in the fields to ascertain from experience in what proportion various particular fertilizers should be mixed to give the very best possible returns at the least possible cost.

This can be done scientifically by every peasant blessed with common sense and a certain amount of observation.

What have the greatest philosophers done but traced results to their final causes and having seen the same cause under the same circumstances produce similar results made a series of statements showing how results must take place always and everywhere when certain circumstances occur before, without which these results would not take place.

One cannot expect for a very long time to come to see, in agriculture, as defined never-failing effects such as we term the laws of nature, because we have yet to learn the many things that effect plant life, but we can all know, in a short time, the result of the manures we use and what to expect when we use them.

The great rule when making experiments is to vary one thing at a time. If I alter two or more things either in the field or the manure I cannot find out which of the changes may have caused the changed results.

If for instance a dish of rice were cooked and proved far from tasty, to learn the cause I should have to use water from the same source and rice from the same store-place and cook it for the same length of time in another pot, to find out whether the pot was to be blamed. I must change only one thing at each trial. If I use another pot and different water, or rice from a new store or boil it longer, and it prove better than the first I cannot possibly come to any conclusion as to the cause why the other turned out so bad.

We must take similar care in testing the value of manures to learn what may be faulty. You may from your own observation and from the well-verified reports of others gain a little knowledge of certain manures during a long life-time, if you simply wait till anything out of the ordinary occurs before you, or is told to you.

But, in experimenting, you regulate things in various ways that would not otherwise occur, and then watch the results that follow. India can boast of thousands of years of observation, but not of much experiment. Cattle manure has been in use for ages, but other manures are not much known.

It is very probable, experience in other places has shown it only too true, that a wise use of fertilizers, other than cattle manure, either alone or mixed with the product of the farm, will bring about astonishing results at a cost well within the means of the average farmer. Now if he makes trials on a small scale and learns what the resulting profit is, it stands to reason he will continue the trials on a larger scale to have so much greater profit, even if he finds it necessary to borrow the money, confident that he will be able to return it and yet have a large margin of the profit for himself when the crop is collected and sold.

Much farmyard manure can be spared and the yield maintained and even increased, by using half the ordinary quantity and thus spreading the dung over twice the area, supplying the deficit by the addition of artificial fertilizers. The value of this will be seen when, instead of placing all the manure on a few acres, no land is left unmanured, and the whole farm is thus kept in heart to produce good harvests.

Of course he should experiment on a small scale till he knows not only the best but the cheapest combination of fertilizers that will give him the best or most paying results, without in any way harming his land.. And to bring this about, he must, on each plot, vary the amount of one of the fertilizers used, and watch the result of these changes. When he sees a certain combination in certain quantities give the best results from a particular field, he may then generalise and say for such fields, with such crops, such results may be expected.

Experiments give the facts on which we may afterwards reason. We may, for instance, find that on certain lands, the addition of even less phosphoric acid or potash than a good harvest requires may give bumper crops. The conclusion we come to from this one experiment is not to be made a rule even for that particular patch of field. All we can say is that the soil contained already so much phosphoric acid or potash that the little addition caused the bumper crop, and as the harvest contains *more than was put into the soil, a certain amount was taken from the soil, which was consequently rendered so much poorer.* A continuation of such a small allowance must soon lead to a lessening of the harvest, till, in course of time, according to the Law of Minima, the field ceases to produce paying, if any crops. Or, as may often be the case with the use of lime alone, foods within the soil are, by its action, rendered available to the plants, a large harvest results, but the store of plant-food has been so eaten into that the raiyat learns the truth of the saying mentioned before :—

> " Lime employed without manure,
> Makes both farm and farmer poor."

But instead of speaking in general terms let us come to the point and see what can be done by each peasant on his own farm. To begin with a few crops as samples, let us try first ground-nut. We know we must as a rule put into the soil what the crop has taken from it. An average crop of nuts removes 100 lbs. of Nitrogen.

30 „ Potash.

24 „ Phosphoric Acid.

But the Nitrogen, we have seen, is taken from the air by the bacteria in the nodules at the roots of the plant, and in feeding themselves, they practically feed the plant with nitrogen, free of cost. The Phosphoric Acid and the Potash come from the soil. Without bothering about the amount of these latter foods that may be present in the soil and entering into the difficult question as to what part of this is available, we simply put at the disposal of plants, by means of manures, at least that quantity that has been as a rule taken up by an average or a bumper crop. The words "at least" are used advisedly, for part of the phosphoric acid and potash may not be taken up by the first crop, and, if it remains in the soil, the plant may be deprived of just so much food if the original supply was poor, or in such a state as not to be easily taken up by the plants.

Starting with these preliminary ideas we should now select a field whose soil is equally good or bad, having the same advantages of moisture, sunlight, drainage, depth of soil, etc. Then we divide a portion into smaller portions of say 22 by 11 yds.; and 10 such will occupy but half an acre.

In order that we may not be deceived by some unforeseen unexpected result from causes we cannot divine, we duplicate each of the five experiments, so that should two of the same set be vastly different we leave them out of our calculations till the cause is discovered. Such a vast difference could, for instance, arise if, on one plot after the ploughing a temporary small loosely-built hay-stack had been erected.

Suppose, however, our plots are about as equal as we can expect to have them, the planning out should be as follows :—

1	2	3	4	5
1a	2a	3a	4a	5a

Learning from experience that it does not pay to use cattle manure with ground-nuts many peasants use no manure at all.

Plot 1 should therefore not be manured, though all the plots shouid be tilled alike, sown on the same day, and throughout the course of growth and reaping, treated as one field.

As 1a is a duplicate plot it also will have no manure.

Plot 2 should receive 5 lb. of bone or basic slag, or if it be preferred and the soil contain more than a sufficiency of lime 5 lb. of superphosphate.

In the first trial only one of these must be used and after a series of experiments with this phosphatic manure another can be substituted as a means of obtaining phosphoric acid.

Plot 3 should be manured with 100 lb. of ashes or 12 lb. of Kainit which contains common salt and other things as well as potash or 3 lb. of muriate or sulphate of potash, but only one of these at a time. In plot 3 the potash and phosphoric acid should be combined.

On plot 4 a very small amount of cattle manure, say, 100 lb. or 10 lb. of oil cake should be mixed with the phosphoric acid and the potash to aid the plants till they draw their nitrogen from the air.

And in plot 5 the full amount of cattle manure used alone, say 500 lb.

The duplicate plots are to be treated in exactly the same way, notes should be kept of the time of sprouting, the appearance of the fields at various stages of the crop's growth, the time of ripening, and the quantity or weight, size, and other qualities of the nuts, and the amount of oil extracted from the crop of each compartment.

In succeeding years, as experience may show useful, one of the manures may be increased or diminished and camparisons thus made.

The largest crop may not be the best paying as the manure may be too dear. There is little wisdom in my spending Rs. 30 on manures to secure Rs. 75, if the difference of Rs. 45 could have been obtained perhaps on an expenditure of Rs. 10.

Care should be taken that the water from one plot should not flow on to the next plot, for that would render the conclusions arrived at incorrect, since the water would probably contain manurial properties on passing over from the first plot. For the same reason as level a piece of ground as possible should be chosen for the site of the experiments.

To save time other experimental plots with an increase of manures may be tried.

With sugar-cane where heavy waterings are required we must not be satisfied to start with only as much nitrogen as the analysis of the crop shows. So much may be washed away in the drainage, and so much, especially in the case of cattle manure, may not be rendered fit for consumption by the plant during the period of its growth, that it is advisable, if a really good crop is to be looked for, to place fertilizers in the soil containing at least twice the amount extracted from the soil by the cane, say, 150 lbs. per acre or 8 lb. per plot, and increasing year by year in trial plots, whilst retaining the bag of 2 cwt. per acre or 10 lb. per plot of bone or superphosphate constant, as also 2 cwt. of sulphate of potash per acre or 10 lb. per plot. Another series of experiments might later on be made with a fixed amount of nitrogenous matter and of phosphoric acid, whilst the amount of potash used is varied from say 2 to 4 cwt. per acre or 10 to 20 lb. per plot, so that in course of time the best combination to secure the best paying crop can be arrived at. When cereals are to be grown similar experiments can be made as those carried out on the Burdwan farm. Though Nitrogen certainlyshows the plainest results in the growth of these crops it is wonderful what effect is produced by potash as a carrier of nitrogen, and numberless experiments in all parts of the world prove that it is always advisable to supply a far greater amount of phosphoric acid than the analysis of the crop shows to have been used. We know that the greatest amount of phosphoric acid is found in the grain, but we are not far enough advanced in agricultural science to be able to tell why the harvest of grain increases so much when an over-abundant supply of phosphoric acid and not merely a sufficiency, is placed at the disposal of the crop. Its action within the plant has not been followed to the same degree as that of nitrogen and potash, and it is quite possible that the excreta from the roots contain a comparatively greater amount of phosphoric acid in combination than nitrogen and potash.

Each farmer should learn for himself by a careful observation of the results of experiments the most paying amount to use.

There is no necessity to go through the list of Indian crops to suggest other experiments that should be made whether with cotton, maize, kadbi, dhal, etc.

As to the value of manures we find in the October issue of 1910 of the Agricultural Journal of India, under the heading, "Concerning Soil Fertility," reference made to Circular No. 142 published by Dr. Cyril C. Hopkins, of the Agricultural Station of the University of Illinois.

On the subject of fertilizers, natural and artificial, much has appeared in the series of pamphlets on "Indian Crops treated from the Manurial Point of View," and the frequent reference to these caused even so friendly a critic as the *Hindu* to give us a quiet dig in the ribs. Quoting from the "Revival of Agriculture in India" the Editor says:—"In some places improved irrigation was the cry raised, and oil-engines and pumps were considered the royal road to fortune; in others, iron ploughs were the instruments to which would—be reformers nailed their faith etc., and then with the smile of the unbeliever he adds ;—"Others again pin their faith to chemical manures and artificial fertilizers as the salvation of the Indian raiyat.'' Even Dr. Mann, in the pages of the Pusa Journal, writes:—"With some of the details of Mr. Kenny's suggestions, we are not in agreement. We do not believe, for instance, that one of the *great* needs of the Indian cultivators is a supply of artificial manures. We have little evidence, again, of the progressive deterioration of most of the land in India which Mr. Kenny considers as certain."

In reply, we can merely say, what is admitted by all, that India has not a sufficient supply of natural manures, that the land has been longer cultivated than Europe and America, and that, if in those countries, manuring is considered the principal cause of the great increase of crops, the use of artificials in conjunction with cattle manure, or alone where farmyard manure cannot be obtained, is *a fortiori* more necessary. The question of price is quite another thing, and does not render the manuring less necessary. It is to be hoped the formation of Agricultural Banks will enable the raiyats to purchase artificials at a rate that will render their use highly remunerative. In introducing the circular referred to, the Editor of the Agricultural Journal asks a very pertinent question :—"Will it also pay in India?" The answer emphatically is :—"Fertilizers in conjunction with farmyard manure or used alone where farmyard manure cannot be had, will pay, provided complete well-balanced fertilizers are employed, and the Department of Agriculture that has for so long used ill-balanced incomplete fertilizers for so many years, is now beginning to see the value of complete well-balanced manures."

As this is a question of the greatest importance, we make no apologies for reproducing verbatim the following correspondence extracted from the circular referred to :—

The following letter was addressed to the Ministers of Agriculture of several European countries, and a similar letter was sent to other leading Agricultural investigators and economists in Europe. This correspondence (giving all the replies received at the date of going to press), is self-explanatory.

" University of Illinois,
Urbana, Illinois, U.S.A.,
December 24, 1909.

To His Excellency

THE MINISTER OF AGRICULTURE,

The Hague, Holland.

" Sir,—Statistical records clearly indicate that in your country there has been a large increase in the average yield per acre of wheat and other cereal crops during the last 80 or 100 years, an increase amounting as a rule to about 100 per cent.

We shall esteem it a very great favour if you will be so kind as to inform me about what relative proportion of this increase you would attribute to each of the following factors :—

(1) To the use of improved seed.

(2) To the use of plant-food in commercial fertilizers and stable and green manures.

(3) To better rotation of crops.

(4) To more thorough tillage.

" Without doubt you have sufficient information concerning the changes that have occurred in your agricultural practice during the last century to enable you to designate somewhat closely the relative importance of these several factors in effecting the increase over the former yields and your opinion in this regard will be highly appreciated by us.

With deep respect,
I am very sincerely yours,
(Sd.) CYRIL C. HOPKINS."

"THE HAGUE, HOLLAND,
January 13, 1910.

"Dear Sir,—In reply to your letter of December 24th, 1909, I am pleased to inform you that indeed the increase in the average yield per acre of the cereal and other crops in the Netherlands during the last 80 years has been very important. The following figures show that very clearly:—

AVERAGE YIELD PER HECTARE IN HECTOLITRES.

	1851–1860.	1891–1900.	1906–1908.
Wheat ...	19·3	24·9	32·4
Rye ...	18·0	21·0	23·5
Barley ...	32·8	41·8	46·5
Oats ...	32·4	42·4	50·0
Potatoes ...	120	181	211

"As to your question to inform you what proportion of this increase I would attribute to each of the factors mentioned by you, I am sorry to say that I consider it to be impossible to state these proportions in figures, because a great number of factors, one dependent upon the other have worked together.

For instance, the use of improved varieties of seed has largely contributed to the increase of yield per acre, but without better manuring and tillage of the soil these new varieties would not have shown any results at all.

Therefore I can only say that the largest proportion of the increase of different crops in the Netherlands I would attribute to the proper use of commercial fertilizers and to the use of improved varieties of seed, the other factors coming in the second place.

I am, dear Sir,

Yours faithfully,

for the Director-General of Agriculture,

(Signed by the Deputy Director-General.)"

"ROTHAMSTED EXPERIMENTAL STATION,

HARPENDEN, ENGLAND, *January* 17, 1910.

Dear Dr. Hopkins,—I find some difficulty in answering the questions in your letter because it is impossible to reduce the factors one surmises to have been at work to the state of figures. As far as I can come to any conclusions I should say the great increase in production dates from about 1835; it has been almost contemporaneous with the Rothamsted Experiments. Lawes describes the Rothamsted land as yielding on an average 20 bushels of wheat when he took possession; to-day I should put the average yield at about 36 bushels—I don't think 40 is regularly got.

The factors at work in the increase have been:

(1) Shrinkage of the area devoted to wheat and other arable crops. The best land has remained under cultivation: the worst has been laid to grass. The wheat area in England in 1866 was 3,126,431 acres and has become to-day 1,548,732 (1908). You must allow a 10 to 15 per cent. increase in yield per acre on this account.

(2) Improved seed does not count for very much. We still grow a good many varieties that *were known 80 to 100 years ago, e.g., red Lammas, Rivette, Roughchaff white, and they are still among the good if not the* best yielders. I should not put down more than 10 per cent. of the increase to the new varieties.

(3) Better cultivation and tillage. This is a difficult matter to estimate, but from all the accounts that have been handed down to us the progress in cultivation has been toward cheapness rather than toward absolutely better work. For example, the old English wooden plough is still to be found : it does first class work, if anything better than the iron plough, but it requires four horses, a man and a boy, where a modern plough will go with one man and two or three horses. Probably there has been some general levelling to the standard of work of the better farmers, but I should expect the best tillage of 1,800 to be no worse than that of to-day.

(4) The great factor has been the introduction of fertilizers and purchased feeding stuffs. As soon as you can introduce on a farm some extraneous source of fertility you can raise the standard of production. Of course many of the best farmers buy little fertilizer beyond superphosphate for their turnips, but they bring in fertilizing ingredients all the same in the cotton and

linseed cake, the maize, gluten meal and other cattle foods which are used to a greater extent than fertilizers.

These of course are only opinions, but in the absence of all statistical evidence they are the best I can give after a good deal of consideration before of this particular problem.

(Sd.) A. D. HALL."

"ROYAL AGRICULTURAL EXPERIMENT STATION
OF THE UNIVERSITY OF GOTTINGEN,
Gottingen (Germany), *January* 17, 1910.

"Honoured Sir,—You ask me four questions that are very difficult to answer. The four factors operate very differently in the manifold combinations together as well as upon different kinds of soil.

When I give you the following figures as you request, I do so with a feeling that they are open to attack in the highest degree. The estimate is dependent upon every condition. I believe that the principal increase of the harvest is to be attributed in part to the application of artificial fertilizers themselves and in part to their combination with green manures. Through the application of the two the yield upon the average has been doubled on our common light soils. In some cases the yield has even been increased two and one-half to threefold. Clay soils become tillable to a greater degree when application of artificial fertilizers are made.

In general I assume that of the 100 per cent. increase in the yield can be attributed :—

To artificial fertilizers, 50 per cent.

The effect of artificial fertilizers is increased through the better tillage of the soil. To this cause I attribute 25 per cent.

To the use of better seed, 15 per cent.

To the better crop rotation 10 per cent.

However, I repeat, these are my own estimates, the exact basis for which is truly lacking. If these estimates will be of any value to you, it will indeed give me the greatest pleasure.

Very truly yours,
(Sd.) VON SEELHORST."

" AGRICULTURAL CHEMICAL EXPERIMENT
STATION, HALLE, A. S. (Germany),
January 28, 1910.

"Honoured Sir,—The greatly increased yields we are now producing in Germany of our different grain crops, especially of wheat, are dependent upon all of the four factors you have named :

1. Upon the use of improved seed.
2. Upon the larger and more intelligent use of fertilizers, especially of artificial fertilizers.
3. Upon a better rotation of crops.
4. Upon more thorough tillage.

Of these factors, however, the use of fertilizers takes first rank very decidedly in increasing the crop yields. That the yield is also dependent upon the rotation of crops you are of course aware. Thus we harvest, for example, 60 bushels of wheat per acre, on our better lands when manured for a previous potato crop, while this yield could be secured after the gross feeding beet crop only by heavily fertilizing the wheat.

Very truly yours,
(Sd.) SCHNEIDEWIND."

"REPUBLIC OF FRANCE,
PARIS, *January* 28, 1910.

Sir,—Under date of December 24, you addressed to me an inquiry with the purpose of obtaining data on the causes of increase during the last 80 years of the yield per *hectare* of cultivated land.

I have the honour of sending you under the enclosure the elements of a reply to that question and I am ready at your bidding to furnish you any other information on the matter.

Accept the assurance of my highest esteem.

The Minister of Agriculture,
(BY THE DIRECTOR OF AGRICULTURE).

In France the land suitable for the production of cereals falls, in great part, into two large, sharply defined groups.

1. Those in which plants of industrial importance, the sugar beet particularly, occupy a very important place in the rotation of crops.
2. Those in which plants requiring intercultivation are, in general grown but very little.

I.—(Intensive Agriculture).

In the Districts devoted to industrial production the farmer has put into practice all known aids to an increase of yield; usually he has carried his operation methodically. In the first place he has begun by preparing his land more thoroughly, by deeper tillage, and by ridding of the noxious weeds that infested it. In the second place, due to the large number of live stock, whose maintenance has been made possible by the *residue from industrial processes and by the extension of forage culture, artificial pastures, (especially alfafa, clover and sainfoin,) he has considerably increased the* production of farm manure, a commodity which has for a long time been supplemented by commercial fertilizers. These two improvements having been once effected, the introduction of more productive varieties of *stiff-strawed* cereals has become a necessity, because it was found that the old varieties, nourished by too rich a soil, invariably lodged before maturity, and yielded only a mediocre quality of grain.

The rotation of crops in the Industrial districts *as well as elsewhere* has remained practically as it was 50 to 80 years ago. The length of the rotation of crops from the same land and the order of rotation has scarcely varied. The principal fact to be emphasised in this connection is the increasing scarcity in the industrial district of fallow lands, which have been almost completely replaced by cultivated crops and artificial pastures.

It is impossible to evaluate with any degree of accuracy, the part which each of these factors has played in the increase of production in cereals, because the result has come from the almost inseparable operation of the combined causes. The effect of fertilizer, for instance, can only be determined in its entirety if the land is very well worked, and if types of soil are selected which are lacking in the particular elements supplied by the fertilizer, and are thereby rendered productive ; moreover the influence of each factor varies between very wide limits, depending upon the nature of the soil and the climate.

If one is willing to content himself with very approximate figures, we submit in the following table, applying to the districts of industrial agriculture, figures representing, as near as can be determined, the relative importance of the different factors (increase in production taken as 100).

Increased use of farm manure and fertilizers	50 per cent. at least.
Better preparation of the land	30 ,, ,,
Selection of seed and varieties improved	15 to 20 ,, ,,

(for oats and barley which have been less improved by selection than wheat, 20 per cent. is certainly too high.)

II.—(Extensive Agriculture).

For the lands of the second group, the farm manures (supplied by live stock becoming each year more numerous as a result of the increased acreage of forage plants, and especially in legumes) play a leading role. Commercial fertilizers are not entirely unknown in the districts comprising this group, but they are often used in insufficient quantities and without sufficient preparation of the land.

The improved varieties are scarcely adapted to existing conditions there and the farmer has had the good sense, in many cases to stand by the old varieties which are hardier and better adapted to these as yet defective agricultural conditions.

The scale of efficiency which it seems reasonable to suppose is as follows:—

Effect of fertilizers	...	70 per cent.
Effect of preparation of land	...	15 to 20 per cent.
Effect of selection of seed and improved varieties	...	5 to 10 per cent.

BOARD OF AGRICULTURE AND FISHERIES,
4, WHITEHALL PLACE, LONDON, S. W.,
1st February, 1910.

Sir,—I am directed by the Board of Agriculture and Fisheries to advert to your letter of the 24th December and to say that while there is no doubt that a considerable increase has taken place during the last 100 years in the average yield per acre of cereal and other crops in this country, the Board would hesitate to place the increase at so high a figure as 100 per cent., and they are of opinion that 50 per cent. would probably be more nearly correct. There are, however, no adequate statistical records prior to 1884, when produce returns were first collected, upon which any accurate estimate of the increase can be based.

In view of the fact that so many considerations have to be taken into account it is not possible for the

Board to discuss within the compass of a letter the relative value of the factors mentioned by you as having contributed to the increase, but, speaking generally, the Board are disposed to attribute the greatest importance to improvements in tillage, including the drainage of land and the use of lime. By draining and liming, the texture of the soil has in many district undergone a permanent change, and the improvement in texture consequent on such operation has rendered possible the use of the improved iron implements now universally employed.

Next in importance the Board would place the increased supplies of farm manure (enriched by purchased oilcake and other feeding stuffs) and of artificial manures.

The Board are of opinion that the effect of improved seed has been much less than either of the causes abovenamed. The farmer of 100 years ago selected his seed grain carefully. Some improvement has, however, been brought about—especially in the case of oats—by the introduction of new varieties.

Changes in rotation have chiefly affected grain crops indirectly by the substitution of green crops for fallow, which has thus increased the manure available on the farm. Cereal crops occupy very much the same place in a rotation as they did a century ago, and while changes in rotation may have been made in order to obtain the full advantage due to improved tillage and an increased supply of artificial manures, these changes should not be regarded as the primary causes of the improvement in the yield of cereals which has marked the past century.

The Board have dealt only with the points indicated in your letter, but it must be borne in mind that, in addition, there have been other contributory causes, e.g., the general increase of knowledge among the farming community and the withdrawal of inferior land from arable cultivation owing to the fall of prices.

I am, your obedient servant,
(Sd.) T. H. MIDDLETON,
Asst. Secretary."

"DEPARTMENT OF AGRICULTURAL CHEMISTRY,
BACTERIOLOGY AND PLANT-BREEDING,
KAISER-WILHELM-INSTITUTE FOR
AGRICULTURE, BROMBERG
(Germany), *February* 2, 1910.

Honoured Sir,—According to my view each of the four factors set forth by you has an essential part in effecting the total increased in yield. I attribute the largest share to the influence of systematically selected higher yielding varieties.

The extensive and discriminating use of artificial fertilizers has likewise contributed very essentially to the increase in yield.

Less important but always noteworthy is the improvement in the handling of animal manure. Indeed the proper care and best use of animal manure (particularly for hoed crops) is always of great interest, so that its application to the field is without doubt more to the purpose than formerly; but fundamental progress in this line can scarcely be recognized. On the other hand green manuring, especially in the very humid parts of Germany has been of great importance and has contributed materially toward the improvement in the culture-condition of the soil.

Through the introduction of the yellow lupine into Germany in the fifties, and the achievements of Schultz-Lubitz in the eighties of the last century, very significant progress was made in this line ; and it must be granted that about 500,000,000 lbs. of nitrogen are annually secured from the air through the activity of the root-tubercle bacteria associated with the legume crops grown in Germany and for the most part this is turned into the soil. More recently green manuring has also been practised on the better lands and with good results.

Better rotation and tillage have also contributed materially toward the increase of our grain crop. Until the beginning of the nineteenth century the common three-field system* with its small yield prevailed throughout Germany ; grass crops having been introduced into the rotation only in certain sections.

The general adoption of our better rotation systems was brought about by Thaer's work and teaching in which has been included hoed crops, and in the last decade they greatly expanded sugar-beet cultivation. The heavy soils have thus been greatly improved. Of fundamental importance in successful sugar-beet culture is the condition of the field with respect to moisture and drainage, and in consequence great areas of our arable

* This usually means one year of fall-sown grain (as winter wheat or rye) one year of spring grain (as oats or barley or spring wheat) followed by one year of fallow in which more or less weeds are ploughed under.—C. G. H.

land have been drained since the middle of the last century, and this improvement has also made possible the higher yields of grain.

It is difficult to express in figures the relative influence of each of the four factors you have named in bringing about our total increase in yield.

With highest respect, I remain,
Very truly yours,
(Sd.) GERLACH."

"KONIGSBERG, I. PR. (Germany),
February 5, 1910.

Honoured Sir,—Your questions are very difficult to answer within the limits of a letter.

The progress of German agriculture has been very marked during the last 30 years. I attempt to answer your questions briefly as follows :—

1. The improvement of seed has had much influence during about the last 10 years, and each year more emphasis is being laid upon seed improvement.

2. The use of commercial fertilizers increases from year to year and they are now more largely used in Germany than in any other European country except Belgium. Commercial fertilizers have contributed very largely to the increase in yield of our field crops. We are striving by their continued use to raise our yields still higher, and this result is slowly but surely being accomplished. We make better use of stable manure

than formerly and green manures are used with good results in sandy soils.

3. The rotation of crops has not changed materially during the last thirty years. In general good crop rotations are practised, but they have had no great influence upon the increase in crop yields.

The better preparation of the soil has been important because deeper cultivation has become more general. This is a matter of much significance in our agriculture.

Very truly yours,
(Sd.) STUTZER."

"AGRICULTURAL EXPERIMENT STATION,
DARMSTADT (Germany),
February 10, 1910.

Honoured Sir,—I have delayed answering your esteemed letter, because I wished to send you with my reply, a little publication, from which you will see that the yield per acre which we have already attained are those which may yet be secured by more intensive fertilizing. In this publication I have written only regarding the fertilizing of meadows, but in other publications you will observe that there are not only hungry meadows in Germany but also still many hungry fields whose yields may be further increased by fertilizing more heavily.

It is evident, however, that the increase in yield which may be obtained solely by soil enrichment has a limit and this limit has already been reached in many cases in Germany. If we wish to secure still larger returns, the result is not to be achieved, on very many farms, only by the application of more plant-food; but it will also require better preparation of the soil, the use of the best bred seed of the best varieties, the best care of the crops, eradication of weeds, etc., in order to maintain conditions under which the highest possibility is afforded for the larger amounts of plant-foods to be transformed into plant substance.

During the last decade we have been working much in this direction and with large results also. Machines for the better preparation of the soil have been forthcoming; the weeds are destroyed, the soil is worked better and to a greater depth; and by means of green manures, especially the humus content of the soil has been increased. More suitable varieties of plants have been bred, attention has been given to these better bred varieties, investigations have been conducted to ascertain the best amount of seed to plant, the best distance to allow between rows in planting, etc.

It is difficult to say, however, which factors have contributed, most to increase the yield. If one surveys the last 40 years, it can well be said that the increased yield of the first 20 years was produced especially by the use of fertilizers, but during the last 20 years we recognize the influence of the other factors, which in connection with the ever-increasing use of artificial fertilizers have resulted in raising year by year the average crop yields of Germany. We have not yet reached the goal, however. In all lines of Agricultural production a significant increase is still possible.

Very respectfully yours,

(Sd.) WAGNER."

These few words will, I hope, prove sufficient to put the intelligent raiyat on the fair way to make for himself the necessary discoveries that will help him to increase his returns, get, by degrees, fairly independent of the money lenders, and improve the lot of himself and his family.

RICE.

Dhanya, one of the Sanskrit names for rice, means the supporter or nourisher of mankind. It is the staple article of diet for more than half the human family. But it is a mistaken notion that throughout India rice is eaten daily by all. In many parts of the country it is a luxury, and, even where plentifully grown, it is supplemented by cheaper and coarser articles of food. So much, however, is thought of this cereal in Bengal, the greatest rice-growing district of India, that, after new rice has been reaped, a grain measure is filled with the fresh unhusked rice, pieces of gold, silver and copper coins, and cowrie shells, and these are worshipped as the representative of the Goddess of Fortune, and, on the Thursday of each of the three following months, it is brought out for further worship. In the ordinances of Manu food is used as synonymous with rice.

As the field crop in the Malay Peninsula is termed padi, the English called unhusked rice "paddy," whilst the word 'rice' appears to be derived from 'ari' to separate, hence Tamil 'arisi' for husked rice.

The total area under rice in all India is 68 million acres, of which 40 millions are in Bengal, 6 millions in Madras, 6½ millions in the United Provinces, nearly 4 millions in the Central Provinces, 1 million in Assam, ¾ of a million in the Punjab, a similar number in Coorg, and comparatively small areas in other provinces.

Accustomed as we are to find the plant spoken of merely as rice it is somewhat surprising to learn that there are, in Bengal alone, 4,000 different sorts, suitable for different soils and climates. And yet the Indian peasant knows the various kinds and the right places in which to grow them. Mr. C. B. Clarke, an experienced and accurate botanist, speaking of the marvellous intuitive knowledge possessed by the hereditary paddy-cultivators, in recognizing the different kinds of rice, says :—"I do not know how, in the young state, the cultivator tells the *uri* (wild rice) from the *aman* (winter rice). I cannot." And Dr. Watt adds .—"It is far more surprising to find the cultivator pick up a handful of dry grain and affirm that it would be found suitable to a particular method of cultivation, while he rejects an almost precisely similar grain as unsuitable." With reference to this, Dr. Watt notices a remarkable fact, viz., that the rices of one district are often so different from those of another that, if interchanged, the one will not grow on the fields on which the other has flourished for centuries, and remarks:—"Here the European farmer is confronted with a problem scarcely known to scientific agriculture ; but although it is so difficult to follow his reasonings, the rice-cultivator of India will detect the one from the other with a perfectly marvellous degree of certainty." And yet we have good earnest souls out fresh from Europe endeavouring to teach the raiyat how to select seeds !

Water is apparently the one thing needful for the growth of paddy, and the Indian raiyat is in accord with the Chinaman in his belief that it is more important than seed, manure, tillage, etc., for the plant appears to grow in any climate and adapts itself in the most wonderful manner to various soils. from the stiffest clay to the lightest of sands, flourishes on peaty soils and produces abundant harvests on lands occasionally saturated with sea water. It can be grown even on *usar* or saline clay, provided that an ample supply of water be given and evaporation from the soil be checked by never allowing the surface to become dry.

Of the 40 million acres under rice in Bengal, 33 millions are devoted to the *aman* crop or winter rices. They ripen on inundated fields and are, in consequence, called the floating rices.

Of these the *Cholan aman* is sown generally in seed beds and transplanted when about 9 inches high. It does not require deep water. It is sown in May, and reaped in October-November.

The *Boran aman* is a coarser form, grown regularly in deep water. It is broadcasted in low-lying bottoms called *bhils* and reaped in December or January.

The *Boro* crop is transplanted from the seed bed or sown broadcast from December to February and harvested in April and May. It grows an abundant crop of coarse rice, used by the poor ; the Shatia taking 60 days to ripen from the time of sowing. As the crop is obtained in the hot season it helps to lower the rates of other classes of rice which have by then gone up in price.

The *Boro* crop can grow in ten or more feet of water and is known to shoot up 12 inches in the course of 24 hours, as the country becomes inundated.

Sown with it is the *Raida* rice and when the *Boro* crop is removed the young stems of the raida are also cut, but they continue to grow and the paddy is harvested in September or October, being 10 or 11 months in the field.

The *Aus* or *Bhadvi* crop is sown broadcast in April-May, on high sandy soil not inundated during the rains. It is harvested in July-August. It is the least valuable of rices and forms about one-sixth of the Bengal crop.

Thus we see that rice is harvested in Bengal all the year round :—

1. Aus harvest	...	July-August.
2. Cholan aman	...	October-November.
3. Boran aman	...	December-January.
4. Boro	...	April-May.
5. Raida	...	Sepetember-October.

As cowdung is used for fuel all over Bengal, one would fancy that the importance of manuring is not known. This is, however, far from being the case. It is known well enough even when not put into practice. Every cultivator has his manure heap, and though he burns the dung for fuel, the sweepings of the house and of the cattle-shed are carefully preserved, and the dung of the cattle during the rainy months. In Bengal, where the population is dense and each family holds about 4 acres, there is sufficient manure for about ¼ of the land farmed. This, however, is not, as a rule, used for the paddy crops. But, wherever the straw cannot be used for fodder, it is heaped on the land and burned with the stubble. Where manure is procurable it is generally used in the seed beds prepared for transplanted paddy, and only when there is enough and to spare and it is not required for better paying or more exhausting crops, is it spread on the land where paddy is sown broadcast. In some places *aman* lands receive 20 baskets of dung per bigha. Some well-to-do raiyats in the Burdwan division manure a bigha with a maund of oil-cake. Four tons of cowdung is considered a good dressing for an acre, but few raiyats can afford this amount in Bengal. For Motihani, cowdung is used and ashes. In Watt's Dictionary of Economic Products the ashes are said to be used to destroy weeds. Yet all over the country ashes, wherever obtainable, are used for all crops requiring a heavy potash dressing, and there is no doubt that it is for this purpose the raiyat employs it, knowing, from tradition and experience, its utility, though he may not be aware of the chemistry of the crop grown, nor of the action of the potash on plant life. The raiyat everywhere admits that the application of cattle manure to the paddy fields is beneficial, and peasants somewhat better off do use it and get better crops than their neighbours, but the raiyat's stock is too limited to spare manure for transplanted rice, though he manures the nurseries heavily. Where the population is dense there is, of course, a larger supply of manure, but in no part of India is the natural supply sufficient, and, till now, artificial fertilizers are practically unknown. Experiments have been made and with decided success, but it requires more than an occasional experiment to introduce so great a novelty as artificial fertilizers. Bonemeal was given to certain raiyats and the results were very encouraging, as they showed an average increase of 570 lbs. of paddy per acre by the use of 240 lbs. of bonemeal, costing 6 rupees. Dear as this is, the increase was Rs. 9-8, so that even the first crop paid for its use. In 1905, the Director of Land Records and Agriculture, Bengal, issued the following interesting results of the experiments for 12 years with manure on paddy lands in the Burdwan Farm :—

	Nature and quantity of manure per acre.	Outturn per acre—Average of 12 yrs. ending 1903. Grain lb.	Straw lb.	Cost of manure per acre. Average of last 3 yrs. RS.	A.	Profit per acre. Average of last 3 yrs. RS.	A.
1.	Cowdung, 100 mds.* ..	3556	4479	4	6	86	5
2.	Unmanured ..	1374	2174	..		16	7
3.	Castor-cake, 6 mds. ..	3123	4628	12	0¾	50	5
4.	Cowdung, 50 mds. ..	3461	4630	2	3	58	12
5.	Unmanured ..	1492	2559	..		18	13
6.	Bonemeal, 3 mds. ..	3663	5124	5	8	80	15
7.	Bonemeal, 6 mds. ..	3962	5509	11	0	84	10
8.	Unmanured ..	1549	2541	..		21	5
9.	Bonemeal, 3 mds. Saltpetre, 30 seers ..	4389	6178	9	4	105	0

* 1 md. (maund) equals 82$\frac{2}{7}$ lbs. ** 1 seer, 2lbs. nearly

Remarks.—The figures in columns 2 and 3 are calculated at the average of 12 years (1891-2 to 1902-3), and those in columns 4 and 5 at the average of three years (1900-1 to 1902-3).

Attention is invited to the results of the experiments with manure No. 9, the last on the list, viz., 3 maunds of bone meal and 30 seers of saltpetre per acre. The method of cultivation and of application of manure No. 9 is as follows :—"The bone meal should be spread evenly on the surface at the time of the first or the second ploughing, so that it may get thoroughly mixed with the soil in the course of the later ploughings. It is not washed out by rain. But the saltpetre may be washed out and therefore should not be applied till the seedlings are fairly established after transplantation.

The saltpetre should be mixed with four or five times its weight of powdered earth and spread broadcast over the growing crop. It would be better to apply it in two instalments at intervals of two or three weeks."

Though a notice accompanied this report stating that a certain quantity of these manures was available for free distribution to raiyats on application to the Overseer, Burdwan Farm, on the mere condition that the applicant should leave his name and address and promise to report on the result of the experiment, it is doubtful if many availed themselves of the free gift offered. It is not known how far the notice was spread among the cultivating population, and, even if they were aware of it, it is quite possible the Indian farmer considered the whole thing as a ruse on the part of Government to ascertain the real produce of the land and possibly to raise the land-tax. Anything is possible, and more extraordinary things are probable in India.

But it is not owing to the want of manuring that scarcity arises. It is to the failure of the rains in September and October that all famines in Bengal have been due. How far, however, short years, which are of more frequent occurrence, arise from the depletion of a wonderfully rich soil, it is difficult to determine. One thing is certain that in ordinary years the use of a well-balanced fertilizer would increase the harvest enormously and its continued application would so improve the paddy crop that the present poverty of the peasant would soon be changed into comparative wealth. It is true that, when bought in small quantities, the outlay on artificial fertilizers is somewhat heavy for the Indian peasant, but in the *gata*, or mutual help system observed in some villages, where 5 or 10 raiyats, each the owner of a plough and a pair of bullocks, form a club for ploughing their lands in *common, we have the nucleus of co-operative societies, which would enable the small farmers to buy manures* on credit, the vast increase in the harvests enabling them to pay their debt and put by a part of what was left for future purchases of fertilizers.

The average return of paddy per acre, according to the Journal of the Agri-Horticultural Society of India (Vol. I, New Series, 1867), is 27 to 33 maunds of paddy. But Dr. Watt thinks this more than double the yield over the total area, which he places at not more than 10 maunds per acre or 827 lbs. of grain. In the Madras Presidency, Tanjore, Godavery, Kistna, Malabar, and Canara are the chief paddy-growing districts. The yield ranges from 6 to 40 maunds or 480 to 3,200 lbs. of grain, the average being 1,200 lbs. On good wet land three crops can be raised in the year, on fairly moist land two crops, and on uplands one crop.

The nurseries are heavily manured with dung, ashes and rubbish. That manuring is thoroughly appreciated in Southern India is evidenced from the fact that every kind of refuse procurable, except human excrements, is used in the manure heap. The District Manual says :—"The dung and urine of cattle, goats, and horses, asses, sheep and bats, ashes, lime, sweepings of houses, bark, muck from the tanpit, milk hedge, varagu and other straws are some of the many substances commonly used as manure, and it appears that many of them are applied only in particular circumstances and on highly scientific principles. The practice of diluting manures with large quantities of water seems to be known to the raiyat, and various modes of making, altering and correcting soil are well understood."

Fields on which two crops are raised per annum are manured every year; but single crop lands are manured only once in every 5 years.

As a rule manure is not considered essential, when water is sufficient, unless the land is poor. But under tanks and wells the fields are manured heavily and great pains are taken to obtain it, sheep being penned on the land, refuse and ashes ploughed in and silt from the beds of dried-up tanks spread over the fields in small holdings. All over the presidency leaves of trees are used as manures. The knowledge of the virtues possessed by the leaves of certain trees is widespread over India. An interesting paragraph from Watt's Dictionary of Economic Products, illustrates this clearly :—" The leaves and twigs of the "*Adhatoda vesica*" are used in rice fields to kill aquatic plants. I doubt if this is the only purpose for which they are employed and it appears pretty plain that their purpose is not manurial, as stated, for they are gathered off the field when the water has gained an objectionable flavour and the aquatic plants are killed before the rice crop is sown or transplanted, though sometimes it is ploughed in. Instead of the *Adhotoda vesica* or *Basuti*, *the Cedrala Toona* (the Toon) or *Melia Azadirachta* (the Neem) is used." Again is added " when only a manure is required." Though these may be the only plants used as manures in the Sutlej Valley, the leaves of a great number of other plants are scattered over the paddy fields in the Madras Presidency and allowed to rot when ploughed in, so that one would have expected a deeper study of this particular subject from the Agricultural Department, considering the remark that immediately follows, viz. :—" In all these cases it will be observed that plants which possess powerful properties are resorted to in place of numerous other weeds, which might more conveniently be used. This same idea seems to prevail in many other parts of India—as, for example, the almost universal opinion, that the leaves of "*Calotropis Gigantea* (the *Ak* or *Madar*—a plant with a most powerful milky sap) is a valuable manure for rice land and a specific against the injurious growth of *reh* (alkaline) efflorescence. It is difficult to understand what particular merit that green manure could have, or any other green manure, in neutralizing the *reh* salts unless it be that suitable acids are freed in the course of decomposition, but, as remarked, the idea that it does possess some such property is very widespread in India." And here follows a remark which brings us as near as possible to the true solution of the question as to the value of these green manures and their real action in the fields, viz.:—"It is most noteworthy that the green manures in most general use in India are, like the *Basuti*, as far removed chemically and botanically as they well could be from the crop intended to be cultivated and are plants with powerful active principles. It at least seems more natural to suppose that the strongly foetidly scented leaves would impart an injurious flavour to the water sufficient, as is believed in the Sutlej Valley, to kill aquatic weeds, than that a few twigs of this plant could have a special merit as a manure. If this supposition prove correct, it may further be found that the habit of using the plant in the construction of wells (a use reported in the Oudh Gazette) may be connected with the knowledge that the green scum so common on every sheet of water in India will not be found in the presence of a few twigs of this plant." In Chingleput (Madras), it is used with other leaves employed as manures and is in special request for saline soils. In South Arcot and in the Kistna District it is believed to be beneficial to crops blighted or diseased, and in several districts it is spread over paddy nurseries. In Coimbatore it is grown in hedges around betel gardens and, though certainly not a manure in these cases, is there of set purpose and proves its utility. That the purpose is not that of manuring is clear from the fact that in the Kangra the plant is burnt by the washermen, who use the ashes for washing clothes in place of carbonate of soda (sajji mutti). One would scarcely think of adding carbonate of soda to alkaline soils already overcharged with it, and the object to be obtained can scarcely, therefore, be manurial. Perhaps we shall come near to the point if we remember that in Ceylon all villagers believe in the virtues of Keppetiya (croton lacciferum) as a manurial agent and use it in betel and garden cultivation, and that there all aromatic smelling leaves are said to be valuable as fertilizers. Mr. J. B Carruthers came nearer the mark when, at a meeting of the Northern Districts Planters' Association (Ceylon), he spoke on Plant Sanitation, beginning with the remark that sanitation was recognized in human medicine and with animals, but was not as yet recognized with regard to plants. People understood, he said, that dead bodies should not be left lying about and other such rules, and he wished to impress on them the necessity of observing the same rules as applied to plants.' I shall return to this point when treating of *rabing* as practised in the Bombay Presidency where rice is grown in districts where the rainfall is very heavy. It is important in a country like India where the same crops are frequently grown, year after year, on the same fields with little or no rotation, and is the only explanation of the sudden widespread and deadly attacks of disease that ruin the crops of a whole district.

As mentioned before, manuring is well understood in the Madras Presidency and very much resorted to wherever sufficient is available. But even where the crops are considered well manured practical experiments with well-balanced artificial fertllizers prove that a great and paying increase can be obtained, and that if all the fields as well as the nurseries were fertilized there would be an immense increase in the harvests.

The following are a few reports of successful trials :—

VIRINCHIPURAM, NORTH ARCOT,
3rd January, 1903.

Your letter of 2nd instant to hand. I am sorry the experiment is on very poor soil, slightly sour and hitherto totally neglected by lease-holders. With all that, the standing crop is very good and for many years past not known to have been in such a good state, considering the impoverished state of the soil. The result of the application of that splendid fertilizer on that poor land is that the crop is equal to that from the best land unfertilized, and considering the poorness of the soil the result is worth reporting, but as the experiment is not on the best soil, I doubt if the result will be of any value for you to see. If you find it worthwhile you are perfectly welcome to it. The crop will be harvested on Monday or Tuesday. My desire is to take a large area under self-cultivation and use fertilizers on various products and invite you for the result. The lands were all leased out last April and I was then employed. I will have to wait for a time. Two weeks ago I planted ¾ acre plants for nursery beds, ¼ received only one basket of fertilizers. The result is marvellous. If you find it worth reporting I shall make a note of it in my diary and watch results.

Yours faithfully,
(Signed) C. V. SRINIVASA SASTRI.

North Arcot District, Madras Presidency.

Wet land watered by channel from River Palar: about 1½ acre, 2 crops assessment.

Nursery bed was prepared on the 8th August, 1902. Six bundles of leaf-manure used, and the seeds sown on 9th August, 1902. Ploughing commenced from that date and the plants were set on the land thus prepared from the nursery bed on the 8th and 9th September, 1902. The land was divided into six plots and the six plots received equally :—

2 cwt. bonemeal.

1 cwt. kainit.

6 cartloads of farmyard manure and a quantity of indigo refuse.

I considered the quantity of manure was quite insufficient. It was done so on account of two reasons, viz :—

(1) The little faith we had regarding bonemeal and kainit, and (2) to see the yield for the same amount expended last year in purchasing leaf-manure.

Rain set in and on the 11th and 12th of September. It was so heavy that the crop sustained a damage of about 5 per cent., and as the land was flooded I was obliged to let out water completely on two occasions. It should be noted that the first plot which was not much beaten by rain grew so high that before the heads of grain were well-formed, the plants fell flat to the ground, unable to stand the wet. The crop was harvested on the 4th January, 1903, and the result is shown thus :—

Year.	Manures used.	Cost of manure.	Yield in measures.
		Rs. A. P.	
1901-02.	4 cartloads leaf manure 6 ,, farmyard manure.	9 8 0	759= 2,466 lbs.
1902-03.	2 cwt. bonemeal. 1 ,, kainit. 6 cartloads farmyard *manure and a small quantity of indigo re-*fuse	9 8 0	1089= 3,539 lbs.

Thus the same expenditure on the same land fetched a clear profit of 330 measures (1,072 lbs.) extra. Besides this the land is ready for a second crop (three months' crop). It is a pity that I did not weigh the straw, which to the naked eye will be at least 25 per cent. more than the previous year. The land was not known to have produced more than 600 measures under the leaseholder, who totally neglected it for the past 20 years.

Dry land irrigated by well, single crop tax, about ¾ acre divided into six plots. Two plots received about 35 lbs. bonemeal and only 5 lbs. Kainit. The crop is doing remarkably well and there is a marked difference between this and the other plots. Full report will be given after the harvest, which will be at the beginning of April.

(Sd.) C. V. Srinivasa Sastri.

Experiments with Paddy.

MR. SRINIVASA SASTRI'S LAND, 1¼ ACRES.

RESULTS TABULATED.

Year.	Manure used.	Yield.	Cost of manure.	Price of paddy sold.	Profit.	Excess.	Remarks.
		lbs.	Rs. A.	Rs.	Rs.	lbs.	
1901-02.	Cattle manure, 6 cartloads. Leaf mould, 4 cartloads.	2,466	9 8	46	..	..	
1902-03.	Cattle manure, 6 cartloads. Bonemeal, 2 cwts. Kainit, 1 cwt.	3,539	9 8	66	20	1,073	

(Sd.) C. V. SRINIVASA SASTRI.

VIRINCHIPURAM, NORTH ARCOT,
Dated 18*th February*, 1903.

Experiments with Paddy. Mr. D. S. Newnan's Dry Land, Ranipet.

Lie of the land.

1 2 3

* Terraced fall, 18 inches *

Plot.	Manure per acre.	Yield per Acre.		Excess of manured over unmanured.		Value of excess.	Cost of manure.	Profit on manured per acre.
		Grain.	Straw.	Grain.	Straw.			
		lbs.	cwts.	lbs.	cwts.	Rs. A. P.	Rs. A. P.	Rs. A. P.
1	Ashes, 2 tons Bonemeal, 8 cwts. Cattle manure, 12 tons.	3,484	22	2,400	14½	Grain 52 2 9 Straw 3 4 0	1 0 0 18 0 0 6 0 0	
						55 6 9	25 0 0	30 6 9
2	Unmanured but received overflow water from No. 1.	2,216	14	1,132	6	Grain 24 9 6 Straw 1 7 3		26 0 9
3	Unmanured ..	1,084	7½			Grain 23 9 0 Straw 1 1 9		

11th February, 1903. (Sd.) D. S. Newnan.

RANIPET, *11th March*, 1905.

THE EDITOR,

The Madras Mail.

SIR,

During this season of drought when every nerve has been strained to water a few selected patches that might provide grain for the family during the ensuing year, it is worth the attention of the cultivator to compare those lands that have been manured with the ordinary manure of the country and those which have been treated with concentrated fertilizers. The fertile lands of Tinnevelly and the lime soil of the North Arcot District alike show the decided difference.

Mr. Newnan, who in former years undertook similar experiments, has once more been rewarded with a bumper harvest; whilst the highest yield around Ranipet has been 20 kullums per acre, with the ordinary cattle manure, his return per acre, after the use of Rs. 16 and Rs. 13-10-0 worth of complete concentrated fertilizers, has been $47\frac{2}{3}$ and $40\frac{1}{3}$ kullums per acre, respectively. This at Rs. 2-8 a kullum will show the profit already obtained. A further profit almost as great may be expected from ragy on the same fields without further manuring.

From Tinnevelly Bridge I have the following report, dated 21st February:—

"There is a small piece of paddy land here belonging to the Firm (Parry and Co.), measuring $\frac{3}{13}$ acre. For the crop that has just been harvested I applied a complete fertilizer to the value of Rs. 5-8-8 and the net profit obtained on $\frac{3}{13}$ of an acre is Rs. 11-6-0 or Rs. 49-4-8 per acre.

The piece of land referred to is of very good quality and I was assured by the owners of the surrounding land that the manure would be of no use, as the soil was quite rich enough without it. We have had no rain at all since the seed was planted with the result that a large percentage of the paddy was diseased, but the above result is only for good paddy. None of the surrounding fields have given more than 1/2 crops or a profit of Rs. 25 per acre.

The total yield from the above land was $3\frac{3}{8}$ kottas—previously it had never given more than $2\frac{7}{8}$ kottas."

Yours faithfully,

(Sd.) JOHN KENNY.

Experiment No. 1 with Paddy by Mr. D. S. Newnan, Ranipettai.

Plot.	Manure per acre.		Cost of Manure.			Yield per Acre.														Value of Excess.			Excess of Weight over ord. manure.		Profit of 1 & 2 over No. 3.		
						Grain.				Straw.				Value.													
						Weight.	Value.			Weight.	Value.			Total.			Net.						Grain.	Straw.			
		lbs.	Rs.	A.	P.	lbs.	Rs.	A.	P.	lbs.	Rs.	A.	P.	Rs.	A.	P.	Rs.	A.	P.	Rs.	A.	P.	lbs.	lbs.	Rs.	A.	P.
I.	Groundnut Bonemeal Potash (Kainit)	336 112 112	16	0	0	6 168	117	8	0	3,610	27	0	0	144	8	0	128	8	0	82	8	0	3,543	2,050	70	4	0
II.	Groundnut Conc. Super. Potash	336 112 112	13	10	0	5,293	101	2	0	3,053	23	0	0	124	2	0	110	8	0	62	2	0	2,668	1,493	52	4	0
III.	Cattle Manure	11,200	3	12	0	2,625	50	0	0	1,560	12	0	0	62	0	0	58	4	0	..	..	..	..	..	..	..	..

THE EDITOR,

The Madras Mail.

SIR,

Since writing to you on the result of manurial experiments in Ranipet I have received further particulars of results from Tinnevelly which will probably interest your readers. Three plots of very wet land were selected during one of the worst seasons. Plot I, was not manured at all, and yielded 408 lbs. of grain and 9 bundles of straw of the value of Rs. 14-4-0. Plot II received 9 bandy loads of cattle manure and a half bandy load of dry leaves, valued at Rs. 8-4-3. Unfortunately the seedlings were planted a month and a half later than the proper season and the monsoon failed at the time the crops were ripening. Thus, though the harvest showed 622 lbs. of grain and 10 bundles of straw over the unmanured acre, the net loss, in comparison, was Rs. 1-15-10. Plot III received 2 cwts. and 75 lbs. of our concentrated fertilizer or half the usual quantity, which at Tinnevelly cost Rs. 10-12-0. The return harvested was 1,337 lbs. of grain and 22 bundles of straw, or Rs. 29-9-10 more than Plot II and a net profit of Rs. 18-13-10 over and above the unmanured plot and Rs. 20-13-8 over that manured with the ordinary manure used in the country. Considering that half the requisite quantity of the concentrated fertilizer was applied during a very wet season, the figures speak eloquently.

Yours, etc.,

(Sd.) JOHN KENNY.

Experiments with Paddy, in wet land of very poor quality, 1 acre in extent.

Plot.	Manure per acre.	Cost of manure.	Yield per Acre. Grain.	Yield per Acre. Straw.	Excess of manured over unmanured.	Value of excess.	Profit on manured per acre.	Profit of No. II over No. I.
No.		RS. A. P.	lbs.	Bundles.	G. S. lbs.	RS. A. P.	RS. A. P.	RS. A. P.
I.	No manure.		408	9				
II.	9 cartloads cattle manure and ½ cart-load dry leaves ..	5 6 0 2 14 3	622	10	214 1	6 4 5	* Loss 1 15 10	..
III.	*.* 2 cwts. and 75 lbs concentrated fertilizer.	20 12 0	1,337	22	929 13	29 9 10	Gain. 18 13 10	..

* Plot No. II was planted a month and a half after the proper time and the monsoon completely failed when the crop was ripening.

** The expenses of cultivation were equal in all three cases.

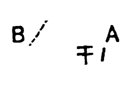
. 1½ cwt. groundnut, ½ cwt. bone, 75 lbs. Kainit. } Concentrated fertilizer.

(Sd.) D. E. Cameron,
Tinnevelly Bridge,
5th April, 1905.

I regret I could not get the returns from field experiments with concertrated fertilizers on reh, soudu or kullur soils. Having succeeded with pot and tub experiments I was glad to see a bumper crop in the field, but though figures for the harvest were promised they were never given me. The crop was as good as that on adjoining good paddy soil, as far as the eye could judge of the ears of corn.

I have the record of only one small experiment, the first field experiment undertaken on soil that never gave any crop though sown with paddy.

Suthar Beg five years ago bought some land, a part of which was certainly the worst specimen of soudu or alkaline soil yet seen by me. To this spot the washermen of the village resorted to gather the surface salts for washing clothes. There were three patches A, B and C measuring respectively 30 cents, 30 cents and 15 cents (an acre is equal to 100 cents). The plots lay thus :—



A draining into B at 1 and into C at 2. The soil had formerly been ploughed, manured and sown, but never returned half of what was put into it, and only the very poorest paddy, kottipollai, that is consumed on the West coast, but had no value as food in the district, was planted. On December 14th, plot A received 2 cwts. of special manure. I regret to say I did not add potash which would have been very useful but was too costly. In this, vellacar, a second class paddy, was sown. In B and C kottipollai was sown about this time, the ground was flooded with the surplus water from the Thundalum and Montthankal tanks and a certain amount of manure was carried off in the rush of water from A to B through the channel No. 1, whilst a little escaped from A to C through No. 2. For six weeks it was impossible to tell any difference in the plots. All were very backward. Then C began to die out gradually till nothing was left growing save in the dotted lines marking the rush from 2. B faded away similarly as far as the dotted lines. A showed bare patches at 3. Some grass covered them.

I regret to say all the three plots were equally neglected as the owner looked opon the experiment as one of the crazy things Europeans will occasionally do in this country. Plot A was not even weeded.

		Grain		Straw.
The harvest was :—	A. Vellacar	150	lbs.	375
	B. Kottipollai	$10\frac{1}{2}$	,,	50
	C. ,,	$1\frac{1}{2}$	,,	...

The analysis by Dr. Ullman of Horn, Hamburg, of the worst sort of this soil, on which even grass would not grow, showed a fair percentage of nitrogen and potash, viz., 0·105 and 0·14 respectively, but the phosphoric acid was as low as 0·024, differing in this respect considerably from the American alkaline soils. To an ordinary dressing with nitrogen and phosphatic manures I added bi-sulphate of potash after it had been neutralized with lime, and the result was far beyond my expectations. As millions of acres of such land lie unused in India it would be advisable to try the effects of similar fertilizers which would act chemically on the carbonate of soda, release the carbonic acid and render the soda an aid to the potash, whilst supplying a sufficiency of nitrogen and phosphoric acid for the needs of the crop. This would probably be very successful in Southern India. Where sulphate of soda is the difficulty some other combination would be necessary, but, though I believe they can be chemically treated with success, I have not had experience with such soils. Heavy dressing with lime would prove a help, besides drainage, but experiments on a small scale, beginning with pots and plots would not prove very expensive, if the chemical affinities of the plant poisons were studied and the necessary ingredients for these changes added to the manures.

The manurial experiments with rice reported by the Bombay Department of Agriculture unfortunately prove of little use to any one.

In 1900 three varieties of rice grown on the Surat Farm were reported upon :—

——	1897-98.	1898-99.	1899-1900.
Kamod ...	1,360 lbs.	2,400 lbs.	1,111 lbs.
Sutarval ...	1,[illegible]60 ,,	1,600 ,,	not grown.
Sukvel ...	[illegible],384 ,,	3,294 ,,	2,128 lbs.

All we learn from this is that "the crops were grown from transplanted seedlings and that the rice beds were liberally manured with farmyard manure each year."

For 1901 we have 3,263 lbs. grain as the Kamod harvest, Sutarval is again not grown, and Sukvel produces 2,355 lbs. In 1903 we have 15 varieties grown with harvests ranging from 1,515 to 3,138 lbs. grain.

What was to be gained by these experiments we cannot guess. It is doubtful if the experimenter himself knew, as he writes:—"Rice is a crop which acquires strong local characteristics, which, I believe, are not preserved when the seed is transferred to other places." And this is all we learn about rice-growing during the year.

In 1904 "a quantity of nitrate of soda was very kindly supplied gratis, through the Inspector-General of Agriculture in India, by the Permanent Nitrate Committee, London, for trials on the farms."

Considering the long continued and very successful experiments on the Governmet Farm at Burdwan, it is passing strange that this Presidency should wait till 1903-4 to try experiments with concentrated fertilizers. There the manures used were complete, here a nitrogenous manure was considered sufficient. When the law of minima is ignored the best fertilizers may prove hopelessly inefficient; and yet it takes years before the sensible way of doing things is commenced. Even with the best results nothing could be proved except that during certain seasons those particular plots, having a sufficiency of the other manurial ingredients, benefited considerably by the application of a very important fertilizer for cereals. But no general deductions could be drawn from such applications.

On the Surat Farm in this particular case, with 90 lbs. nitrate of soda used per acre, the harvests were on three plots:—

Unmanured ...	1,029 lbs.	1,714	1,020
Manured ...	1,748 „	2,535	1,582

telling most decidedly in favour of nitrate of soda, an expenditure of Rs. 4 giving a return of Rs. 17. But even in the same spots, in course of time, it is more than probable that applications of the same fertilizer would result in rapidly diminishing harvests. On plot 3 at Pardi town the unmanured plot gave 2,514 lbs. grain for the harvest against 1,367 lbs. when the nitrate had been used. This is called abnormal, but no attempt is made to trace the cause. No analyses of the soil were made in order to ascertain if any plant-food ingredient were abnormally low. Had this been done, probably nothing abnormal would have been found, but it would have been decided that the return was what was to be expected.

The reason given for the abnormal return is remarkable. It is not difficult to understand that nitrate of soda would be less efficacious in a sandy soil than where a fairly stiff clay is to be found and this might explain a very slight difference in favour of the manured plot, but it cannot possibly be a sufficient reason for an unmanured plot giving a harvest nearly twice as great as that from the manured plot.

On the Nadiad Farm the experiments would disgrace a first year student at an Agricultural College. Five plots were manured with 15 tons of farmyard manure and five others had the same manure plus crude nitre (66 per cent. potassium nitrate).

The increase on the fields treated with nitrate of potash were 35, 90 and 305 lbs. grain, the decrease 20 and 100 lbs. The differences in the soil and the quality of the farmyard manure could easily account for the variations. The price of the nitre would have been more productive of good had it been given for sweets to the neighbouring raiyats. The desperate attempts to account for the difference are not even amusing.

In the "Appendix to the Poona Farm Report" for this year we have an account of experiments with "crude" saltpetre as a manure for rice, in the Thana District (7 experiments at Pursik), Kolaba, (5 experiments at Chouk), and in Poona (2 at Khadakwasla and 1 at Manjri).

That bungling should take place we are not surprised to learn.

1. Under "Previous History" the words occur:— "An attempt was made to ascertain whether the varieties were the same in duplicate plots." (On this point no information is vouchsafed).

2. Rabed areas were excluded as far as possible, but later it was ascertained that the information first received was not reliable and some rabed fields were treated with nitre.

3. Also it was found that some plots had received manure.

The method of application is not quite intelligible. Why two men were required, "one manuring lengthwise of the plot, the other applying it in a similar manner walking crosswise of the plot" is not clear.

The word "duplicate" never seems to be used by the experimenter in the sense in which it is ordinarily employed at agricultural stations. From his report any second plot is a duplicate, however treated.

The experiments are absolutely contradictory. One would expect that the application of nitrogen and potash would result in a proportionate increase in straw at least, but of the 7 Pursik experiments, 4 plots show an increase of grain in the treated plots, and in those four the increase in straw is quite proportionate to the increase of grain, but in the case of the other three untreated plots the increase over the treated plots is as great as it was the reverse, in the other four plots. Of course no deduction whatever can be made from these experiments.

Nor can we learn anything from the 5 Chouk plots; for, though 4 of the treated plots give a better return than the untreated plots, varying from 25 lbs. to 708 lbs. grain, in No. 11 the variety was not the same in both plots, nor are we given the average outturn of such varieties to enable us to form a judgment, and in 9 and 12 there were small areas of rab, which might account for the differences in the harvest. In No. 10 there were also small areas of rab but the untreated plot resulted in a harvest of 4,572 lbs. grain against 2,061 lbs. in the treated plot, though the straw was only 2,337 lbs. (this looks like an error) in the untreated plot against 2,450 lbs. in that fertilized with nitre.

In the 12 experiments of the Khadakwasla series, 4 of the treated plots are better than those untreated, 8 are worse.

Of Manjri we learn merely that "potassium nitrate, sodium nitrate, and castor-cake were used. Castor-cake gave the best results."

No details are given, no results tabulated, no quantities of manures supplied, and no inquiry as to why a complete (if not well-balanced manure) gave better results than fertilizers containing one, or at most two, of the chief plant-food constituents.

The conclusion is about as illogical as it well might be, but previous reviews have prepared us for these remarkable mental feats. It runs :—"In conclusion, it might be said that on the whole nitre gave good results, but further careful experiments are needed, when all the previous history is known."

In the rab experiments of 1905, although only 10 lbs. of nitre were applied instead of rabing the one guntha seed-beds the return was better than all the 16 previously mentioned plots, i. e., all the rabed plots and the other so-called substitutes, returning Rs. 30, the highest net profit; but, with a fatality peculiar to the use of nitre as a fertilizer by the department, it sinks to the last place, but two, the next year, its harvest being above only the 'no rab' and the 'lime' plots; and in the table of "results from seed beds" it holds the last place with the 'pulverised soil' plot.

Again on page 91 we have three crude nitre tests (no idea of its nitrogenous or other contents is supplied) and the results show a decrease in harvest accordingly as more nitre is supplied, viz., 80 lbs. nitre yields 1,665 lbs. grain, 160 lbs. nitre, 1,380 lbs. grain, and 240 lbs. nitre, 1,050 lbs. grain.

Potash is also tried alone and yields 1,440 lbs., or more than two of the nitrogen and potash plots.

The next year the harvests are very much smaller though the plot manured with twice the amount of nitre gives a decided increase in grain, the potash plot returns only 560 lbs., the 'no treatment' plot falls to 344, and the new idea of using bones results in 320 lbs.

Any attempt at a complete manure appears forbidden. *As to the* '*variety tests,*' it is difficult to know why *these 53 experiments* were made. We are told that the "cost of cultivation is rather high on account of it being our first year"; but, in the statement following the cost of cultivation is put down at Rs. 7-8-4. As it mounts up to Rs. 42 the next year, the puzzle becomes greater. It may be that in 1905 only the rabed seed-bed area was taken into consideration, but in 1906 even this shows Rs. 25-4-6 as the cost of cultivation.

In 1905 we have a harvest of 20 lbs. grain from No. 12 Ghudya Semi Garva, 80 lbs. from No. 25 Rajawal Garva and 83 lbs. from No. 47 Tin Pakhi Kudai. In the table of the succeeding year these are no longer in the list.

Nos. 1, 2, 3, 4, 5 drop in 1906 from 1,300; 1,260; 1,640; 860; and 1,560 lbs. respectively to 306; 340; 791; 160; 302. In fact all down the list we have a similar falling off. The figures are just given in the list, and, if one does not like them, he must needs just lump them. Barring the date of harvesting, there is little information to be obtained from the notes as to characteristics. The play on the words white, red, reddish is neither very entertaining nor decidedly instructive.

It would be a waste of time to go through the succeeding series of nitre experiments; for Chouk contradicts Thana and the results of 1906 are as bewildering.

There is a remarkable note on page 93 of 1905, viz., "It may be that the presence of nitre in the absence jo sufficient water ruined the crops." It would be interesting to learn how, "recently manured fields often suffer in a drought." One would have expected nitre decidedly useful at such a time.

Tests were continued in 1907 with 253 Bengal varieties. All we learn of them is "the yield from each bed (size not mentioned) varied from 2 to 83 and the produce was preserved for sowing in the next year," but we have 5 pages of tables about 239 that were red, reddish, white and greenish and are told that the rest did not germinate. The dates of harvesting are also added. And the sum total of what the year's work teaches us is nil.

Of the 14 selected varieties of the presidency grown in two guntha plots we have a return, but what its value is to anybody we cannot say. In 1905 and 1906 there appeared to be no difference in price for the harvests of the different varieties. In 1907 differences appear but the sale price is not given. As all the field plots resulted in losses, and we are not vouchsafed a line beyond the tabulated statements, we must continue to wonder at the great amount of restless misapplied energy indicated.

Here also we find complete manures used, but unfortunately nothing can be learnt from the ups and downs in different harvests obtained in plots manured in the same manner.

To do any good the department must undertake rice growing on a commercial scale and series of experiments must be tried with definite objects in view.

In 1908 we are spared the terrible tables of white, red, reddish, whitish, greenish, that enliven the pages of the report as notes of characteristics in the variety experiments. We are satisfied to learn that "the produce has been reserved for sowing next year when some definite information will no doubt be obtained." No doubt! We appear to have done with nitre also, except that a single experiment is reported on page 7 in 1909 and another on page 8.

No doubt rice has occupied the attention of the department for many years. If nothing has resulted from it so much the worse for rice. But from the pages of these reports we find no improvement whatever in the cultivation of rice shown by the Department of Agriculture. Experiments with cattle manure supplemented by complete well-balanced artificial fertilizers, or the latter taking the place of cattle manure where it is not found in sufficient quantities may possibly give better and more paying crops than those grown at present by the cultivators, and this appears to us the immediate object the department ought to keep in view.

In the Bombay Presidency we have paddy grown in such extremes of soil as the cotton fields of Broach and the salt marshes of the Konkan. Over 81 per cent. of the total paddy-growing area where the rainfall is heavy and continuous, rabing is in practice. *Rab* means, originally, cultivation, and it is apparent from the very sense of the word that the natives do not think it possible to grow paddy well for any length of time without resorting to it. It consists of burning the sun-baked land in the dry weather just before the south-west monsoon. Cowdung, collected and dried as cakes, is spread over the soil together with loppings from the *ain* (Terminalia tomentosa), dead leaves, inferior straw, pit manure of the wet season, ashes, house-sweepings and refuse and pulverized earth, to exclude the air as much as possible and to enable the whole to burn slowly. These soils, so heavy as not to break easily under the influence of the sun, are thus burnt without any previous ploughing.

Taking the yield of the *rabed* & cowdunged plot at 100
the manured but *unrabed* fields yield 73·5
against the unmanured and *unrabed* 60·3.

In the south of the presidency where the ante-monsoon storms are heavy and allow of sowing in May, the fields are manured, but not *rabed.* The benefits derived from the ashes left in the burnt fields are indubitable, but it is more than doubtful if all the care, attention and trouble would be bestowed on the *rabing* of these fields if the idea of manuring with ashes only were in question.

Watt remarks :—" We know that marsh gas and low forms of carbon or organic acids, which injure crop plants, are produced by decomposition of humus in very wet soils where the supply of air is restricted."

I can quite understand the restriction of the supply of air, i.e., the want of æration in heavy clay soils, but marsh gas and organic acid, say at Lanavla, are not to be thought of. In the Bombay Presidency manuring for paddy is thoroughly understood and practised, but nowhere in India is unnecessary trouble undertaken by the raiyat or expenditure on his lands that will not pay. People may tell him it is folly to burn his cowdung on the land instead of ploughing it into the soil. He has behind him thousands of years of tradition, and I am inclined to think a tradition based on truer science than our present day agriculturists can teach him. It is only a few years ago that the Anglo-Indian newspapers drew attention to Bulletin No. 40 by Oswald Schreiner and Howard S. Reed of the United States' Agricultural Department. Their theory of toxic effects is one suggested a year before at a meeting of the British Association, when the question was raised as to the injurious effects of grass upon orchards. It was admitted the soil lost no plant food, that æration was not impeded and that grass was not parasitic, and so, as no other explanation offered, it was decided the grass must have some toxic effect.

The only explanation we can find for this phenomenon, the only reason that can satisfy us up to the present why in well-manured beet fields the plant will not grow for a succession of years unless, to use an Indian expression, the fields be *rabed*, the cause of the sudden, unaccountable failure of the indigenous groundnut in Southern India, and of the Mauritius sugarcane after a success of 20 years in Bengal, together with the oft-recurring potato blight in various parts of the world, is the theory started some 25 years ago by Dr. Jaeger in his "Soul of Plant Life." The subject is important enough to occupy a few lines in this chapter as I believe Dr. Jaeger's conclusions to be the foundation of much of the Indian rotation of crops and have a great deal to do with the peasants' use of strong scented leaves employed, as is popularly considered, for manurial purposes. The discoveries of science in Europe, during the last quarter of a century, are, in India, the petrified customs derived from hoary antiquity. Some years ago, with loud beat of drum, it was announced that an American had discovered the wonderful power of killing bacteria and algæ possessed by a very slight solution of sulphate of copper. Yet in India this must have been known for thousands of years, every one who could afford it having used copper vessels for fetching and storing water from time immemorial.

The knowledge of leguminous crops and weeds is perhaps greater and more widespread in India than anywhere else. One should not, therefore, be surprised to learn that the customs of the Indian raiyat with reference to *rabing* paddy lands took its origin from the dictates of science in far-off ages.

From the Researches of Professors Wilfarth, Wimmer, and Roemer of Anhault and from Bulletin No. 40, U. S. Agricultural Department, referred to above, it must be admitted that plants excrete. Why this should have been so long denied or have even formed a subject of discussion is a puzzle to me. That plants have different scents is apparent and it is equally evident that the different parts of the same plant smell differently. Now, in animal life, it is recognized that sympathy and antipathy, often the most violent, arise from the odour that emanates from the animal. There are also some animals that loathe the excreta of others and some that feed and fatten on such excreta. Does this sympathy and antipathy, arising from the same cause, exist in plant life? In Theophrast, Hist. plant IV., 16. 6, we find:—
"Certain plants do not, it is true kill others, but they make them deteriorate by their sap and exhalations, as for instance, the cabbage and the laurel act upon the vine. When the vine branches approach them they are said to turn and get out of the way as if the smell were unpleasant to them. Androcydes used this hint to prescribe cabbage as a means against intoxication, since the vine branch even in life avoids this smell."

Jaeger gives a remarkable instance of the antipathy mentioned. He and his neighbours had vines planted in their back-gardens of the same sort and by the same gardener. His neighbours' vines all grew in splendid condition. His were backward and in danger of dying and he could not possibly account for this remarkable difference till he found he had planted cabbages alongside the vines, while his neighbours had not done so.

It is well-known that many species of plants drive other allied species from their neighbourhood. In this relation *Achillea Atrata* stands to *Moschata, Primula Alatior* to *Officinalis, Rhododendron Alpinum* to *Hirsutum.*

There can be scarcely any explanation for this but the smell or effluvia, or, as chemistry may show later, the action of plant excreta, acting chemically on the roots of others, or on the bacteria favourable to their growth.

In many parts of India, a weed, striga, springs up in the fields and around it a circle of dying plants marks its baneful effects upon the crop. There can be no question of the weed's feeding itself at the expense of all the plants in a circle whose diameter is a yard; nor can it be explained in any other way why nothing will grow under the tamarind and why the bamboo and gold-mohur are so detrimental to most other species attempted to be grown under their shade.

According to the new Amercian theory a toxin will have to account for it, but it is just as likely that it is the smell and that alone that sickens and kills the surrounding plants. This seems to be known in India and Ceylon to a certain extent and explains the use of strongly scented leaves on heavy clay soils to enable paddy to be grown year after year in the same fields.

We have seen that in the Bombay Presidency where heavy and continuous rains occur and after the harvest the paddy stubble remains in a soil that becomes hard-baked in this torrid climate, *rabing* is resorted to. This is also in accord with scientific experiments carried on in Germany after beet fields grown with the same crop, year after year, refused to return a harvest. Good soils burnt were renderd worse; bad soils improved wonderfully. In other words as animals love the exudations from their own bodies and thrive when they are not concentrated, sickening when the effluvia is overconcentrated, so also plants love the neighbourhood of others and improve by the exudations and exhalations of their neighbours, till overconcentration of the effluvia in the soils takes place and sickness follows, unless means are taken to rid it of the odour and its cause : and one of these means the raiyat has found to be heat, applied to such an extent as to open out the soil and admit of the expulsion of the odour it contains.

A more careful inquiry into the smell emanating from the roots of fruit trees and from grass, will probably lead to the detection of the cause of suffering in orchards due to grass.

Fallowing cannot be wholly explained as necessary by Liebig's system, since, nowadays, farming is so concentrated that plant-foods are not wanting in the soil. Jaeger's theory can alone explain the sudden rotting of the Mauritius red sugarcane introduced into Bengal and flourishing there 20 years, after which all suddenly died down, owing to the attack of borer, whilst those no more than 10 years in the district were left untouched. In the one case the effluvia overconcentrated in the soil led to sickness which attracted borer. White ants attack wood and by preference decaying wood. A mere layer of charcoal keeps them off. What can explain this but that the deodorizing effect of charcoal prevents them from getting the smell that draws them to their food.

I have gone into the question, because I find certain men, who instead of giving their best attention to the traditions of the peasant and endeavouring to understand the reasons, perhaps lost to the raiyat, of their system of agriculture, condemn wholesale what the raiyat knows to be good, and render themselves ridiculous in the eyes of those they wish to teach. In the cultivation of paddy, for instance, some cultivators are of opinion that the lands ought not to be ploughed in Summer, for this would destroy the grasses and the success of the paddy is dependent on the growth of these grasses. In April-May, after a heavy shower of rain, the land may be once ploughed whilst the soil still contains a large amount of water. Instead of destroying the grasses in wet land it will encourage their growth. Later on, the land being quite saturated, two or three ploughings mix up the grasses with the mud and the seedlings of the paddy are planted. Dr. Watt here remarks :—" There is, no doubt, some truth in the statement that grasses serve the purpose of green manuring ; but that this is a one-sided view of the matter is evident from the fact of paddy grown on lands which are not easily ploughed being often subjected to what cultivators call the disease of *Kadamara.*"

Here again it appears plain that grass is not a green manure but that the effluvia from rotting grass serve to counteract or destroy the concentrated essence from the stubble and roots of the paddy left in the fields from the previous crop.

In the Annual Report of the Department of Agriculture, Bombay Presidency, for the year 1908-1909, we find the following remarks on the subject :—

" The *rab* experiments at Lonavla were continued.

Rab is the name given to materials, such as branches, cowdung or other substances which are burned as a preparatory treatment upon the seed-bed wherein rice seedlings are grown for transplantation in the fields. This custom prevails in the western part of the Bombay Presidency, where the rainfall is from 50 to 200 inches. This system of rice cultivation is objected to because of its injurious effect upon the forest where branches are used, and the waste of nitrogen in the case of cowdung. Investigations of the practice have been going on since 1904 with the objects in view first to find the reason for the beneficial effect of the *rab* and the second to find a substitute. The results of the year are in line with those of previous years, in that they show that the greatest factor in the *rab* is not the ashes but the heat, but how this acts is not settled. Several substitutes have been found to be as efficient as *rab*. Among them are fish manure, nitre, oilcake, sheep folding and cowdung ploughed in. About 120 lbs. of fish, 20 lbs. of nitre, 120 lbs. of karanj or niger oilcake, 80 lbs. of safflower cake, one cart of poudrette, a small cart of farmyard manure or 100 sheep folded for 4 days will give as good a supply of seedlings as ordinary rab. The cost of these various substitutes will vary with each location but in general if rab material has to be carried very far, they will not be very much more expensive than rab.

The experiments in field manuring gave indecisive results probably due to water flowing from one plot to another at the time of heavy rain."

The last sentence is rather puzzling. If "several substitutes have been found to be as efficient as *rab* (and it is quite possible such can be learnt) why have we not a list of experiments, the nature of the soil, the amount of the materials used, per plot, or acre, to take the place of *rabing*, the cost, etc., with the percentage in results for each? Evidently it is early to make so definite a statement when the experiments in field manuring gave indecisive results. But let us examine the whole series of experiments made with a view to the elucidation of this point.

In 1904 it was decided to start once more the experiments undertaken in 1885 by Mr. E. C. Ozanne, Director of Agriculture, Bombay. That a great deal of energy was employed to get to the bottom of the questions to be decided is evident from the large number of tabulated statements published since the trials began 7 years ago.

The first puzzle that meets us however, (and the whole record is a series of puzzles) is the location of the experiments at Lonavla. Mr. Ozanne chose Lonavla, Khandalla, Igatpuri, Karjat, and Alibag, places on and below the Ghâts where rabing is customary. His experiments are interesting and their results in agreement with actual harvests in the vicinity of the experimental stations. The crops obtained were in accordance with what one is led to expect from the long established customs of the country founded on practical experience. The department has lost much in neglecting to continue on the same lines these carefully conducted experiments. To make up for this we find a new series started in 1904. We wish we could speak as favourably of them and the succeeding trials. With statistics it is said one can prove that the moon is made of cream cheese. By use of the figures resulting from these experiments we can conclude anything with each year's tables, absolutely nothing, when the harvests of the last five years are placed side by side.

In the report for the year ending 1905 (it is easiest to refer to it simply as the 1905 report) we have a brief statement of the results of Mr. Ozanne's experiments and the deductions he drew from them, viz. :—" Cowdung rab is decidedly superior to all other rabs. Ain comes next and Fangal is inferior to both unrabed and unmanured plots. Fair results are obtained from leaf and grass rab."

On a first view of the question it would appear that it mattered little what was used as the burning material provided the heat required was supplied, and we find this conclusion jumped at in the very first report, in spite of Mr. Ozanne and in direct opposition to facts, which might easily have been ascertained from the peasants around. In 1907 we have a view stated not quite in consonance with the above. It reads :—" So far as the figures given below prove anything, they indicate that cowdung rab has justified its reputation among cultivators as the best preparation for the seed-bed. The yields are however much too uneven to be reliable." But, as the only thing we can gather from the report is that the figures are hopelessly unreliable because they are so uneven, we can only agree with the conclusion without seeing any logical process of reasoning that led to it. Through the hopeless jumble of contradictory figures there seems reason to infer that the supply of potash in ashes is not by any means the object in view in rabing, nor is heat alone the cause of successful harvests, nor again the apparently more scientific theory, that nitrogen-consuming bacteria are killed in the process and nitrogen-producing bacteria, salamander-like, emerge refreshed from the ordeal. If such were the case, heating in any manner to the same degree of temperature would suffice. Yet, contradictory as numbers of the experiments appear, they certainly allow us to infer that cowdung rabing is better than rabing of any other sort and heating the earth off the field is not as good as the practice of the Indian farmers. This is also in accord with the results we find in the crop experiments made to settle the question of the incidence of assessment.

The experiments were undertaken to obtain answers to the following questions :—

1. What does the efficiency of rab depend upon?
2. What rabs are the most beneficial?
3. Can any substitute for the present custom be found?
4. Will any after-treatment of the crop secure the effects of rab?

No less than 25 experiments were tried at Lonavla as seen in the report of the year 1905. Apparently there were no duplicate plots till 1907, when the 25 experiments became ten only, for rabing and the substitutes that might possibly be used. In 1908 these are further cut down to four experiments in triplicate, and extended to nine in duplicate in 1909, together with three single experiments in which charcoal, lime, and common salt are used respectively to replace rabing.

Before starting the experiments of 1905 an unfortunate mistake appears to have been made in the selection of the soil, which may possibly account for the very remarkable results obtained. On receiving the analyses made by Dr. Leather on samples of rab materials and earths, Mr. Mollison wrote :—" I have the honour to state that the soil, before it was rabed, was surely in fine manurial condition, and, therefore, unusual in character. In all the samples there is a high percentage of organic matter and also high percentages of nitrogen. The rice lands on and under the Ghâts which are usually rabed, are of a very different character, and in order to get reliable information regarding the effects of rabing, it would, I think, be well to repeat the experiments under more ordinary conditions."

The advice was followed in the next season ; but, though in 1905 it was remarked that " Duplicate experiments should be made at other stations," (why at other stations?) no duplicate plots were tried in 1906. In 1905 the plot chosen was rich in the principal plant-foods, nitrogen, phosphoric acid, and potash, and even the unrabed earth was far from poor on the spots selected in 1906.

The results of the first experiments contradict Mr. Ozanne's trials, and appear to condemn everything hitherto done by the farmers. Yet, if we take into consideration the richness of the land, we are not surprised at the results. In Germany where beetroot is grown year after year upon the same land, the soil becomes beetroot-sick and refuses to return a paying harvest. Of course scientists found a scientific cause, viz., the nematodes. They were traced right enough. Instead, however, of ascertaining the causes that made these accumulate, the object aimed at was not to eradicate them, but merely to destroy the visible consequences on the spot. It happened that the burning of the soil removed the nematodes and probably the cause; but it was also noticed that where the land was not yet beetroot-sick, burning, instead of doing any good, resulted in positive harm. Will this explain the extraordinarily divergent reports of 1905 and 1906? It looks like it. We are told that plot 26 "is quite near the town and received some washings, which, no doubt, increased its fertility. Number 51 was a very uniform field which had been out of cultivation for several years, but otherwise it was very satisfactory."

In Mr. Ozanne's experiments cowdung invariably gave the best returns. In the first set of the new experiments cowdung rab gives a loss of Rs. 26, whilst the unrabed plot shows a gain of Rs. 21, and that neither rabed nor manured a profit of Rs. 23.

Is it conceivable that through centuries the cultivators were foolish enough to rab, and to rab with cowdung wherever their means allowed of it, if leaving the soil untreated would give them a difference of Rs. 49 per acre to the good? Yet this is the sort of thing we are led to infer from single experiments, in one place, on badly chosen sites.

Why was not Mr. Ozanne's plan carried out? Surely the Department was no more undermanned in 1904 than in 1885.

Another glance at the tabulated results shows that ashes of rab proves better than heating the removed earth and replacing it, safflower cake is better than both and all three give very much better results than rabing. Yet in 1906 cowdung rab that was down 16th in the list now gives the best return in grain, though it comes second in net profit, and land heated gives a profit of Rs. 9 more, viz., Rs. 33 per acre. Cotton-seed, that in the previous year returned a harvest of 2,780 lbs. grain and 4,020 lbs. straw, valued at Rs. 99, returns this year only 693, lbs. grain and 1,067 lbs. straw, worth Rs. 26, gives a net profit of Re. 0-15-9, and disappears from all future experiments. The safflower cake harvest drops from 2,120 lbs. grain and 3,650 lbs. straw, worth Rs. 77, to 800 lbs. grain and 1,120 lbs. straw, worth Rs. 30, and the plot with no rab and no manure returns about the same. Cowdung ploughed in now gives a better return than cowdung rab, and the harvest of ashes from ain rab drops from 1,720 to 1,400 lbs. grain.

If experiments without duplicate plots rendered it difficult to draw conclusions from the tabulated statements of results supplied, the many plots selected for the same treatment in the Report of 1907 make confusion worse confounded. Here we find the ashes of ain rab not so productive as ain rab itself, but better than mixed branches rab, and cowdung plougded in returning a harvest of 1,420 lbs. grain with a profit of Rs. 16, whilst 8 experiments in cowdung rabing give extremely varying results ranging from 680 to 2,110 lbs., and the profit and loss vary from Rs. 23 to 42.

We have attempted to reconstruct the scattered tables to arrive at something definite, but absolutely nothing can be made of the experiments. Earth pulverized and earth heated are consistent failures this year, the former resulting in harvests of 400 and 480 lbs. of grain, the latter producing 640 and 800 lbs. Even the five safflower plots vary from 978 to 1,760 lbs. grain, while the no treatment plots vary from no harvest at all to 800 lbs. grain. The two poudrette plots give 1,360 and

1,560 lbs. of grain respectively, and the single plot of cowdung ploughed in returns 1,420 lbs.

With mixed branches rab in the seed bed, field applications of manure apparently proved hopeless failures, 20 of the 23 plots showing losses. Of the three in which some gain resulted a cowdung manured plot gave a profit of Rs. 3-10 against losses of Rs. 14, 27, and 36 respectively; on similarly treated plots, safflower produced a gain of Rs. 7-15-3 against losses of Rs. 15, 21, and 34, and no treatment in one plot gave a profit of Rs. 10, and in three other plots losses of Rs. 15, 19, and 24.

We cannot but agree with Mr. Fletcher when he says:—"It is impossible to draw conclusions of any kind from these experiments, the variations between duplicate plots being often greater than between either of the plots and the no manure plots." When he adds:—"The figures are given for what they are worth," we are inclined to mutter:—"They certainly were not worth the cost of printing."

In 1908 we have a further reduction in the number of experiments. These practically resolved themselves into (1) mixed branches rab, (2) ashes of mixed branches rab, (3) earth pulverized, and (4) earth heated, in triplicate, but for the difference between 271 lbs. of mixed branches rab and 1,080. lbs in two other plots. Then come the manured unrabed plots, viz., safflower, cowdung ploughed in, and as a standard, cowdung rab.

The apparent mistake in the amount of rab material in the mixed branches rab plot put us on another problem which also requires elucidation. The plots with 271 lbs. gave a total outturn valued at Rs. 73. With

1,080 lbs. of the rab the outturn falls to Rs. 58. This might possibly be explained by overheating, but, with the same amount of the same rab materials in plot 9 the harvest falls to a value of Rs. 45.

So far instead of throwing light on the vexed questions before the department, another, and a very important matter turns up to be elucidated, viz., the exact amount of heat in rabing that is productive of the most good.

Ashes of mixed branches produced in plot 2 Rs. 50. Though the same quantity was used on plots 6 and 10, there is a uniform fall in value to Rs. 36. The variations in the earth pulverized plots are, No. 3 Rs. 64, No. 7 Rs. 35, and No. 11 Rs. 48. More astounding still are the variations in the earthheated plots, ranging as they do from Rs. 131 in plot 4 to about Rs. 55 in plots 8 and 12. Ain rab returned Rs. 77, whilst cowdung rab ranged from Rs. 137 to Rs. 60. Here again we have the question alluded to above coming prominently forward without any notice being taken of it by the experimenter. The return seems to vary according to the inverse ratio of the amount of rab materials used. With 1,106 lbs. we get Rs. 137 : with exactly twice the quantity the harvest falls to less than half, totalling only Rs. 60.

In 1909, there is one point that does not vary. On the duplicate plots 10, 11, 12, 13, 14, 8 and 9 we have uniform small harvests, as a rule from one-third to one-half of those on plots 1, 2, 3, 4, 5, 6, 7, and yet the only remark we find is the following :—"This is in direct agreement with the previous years' work that heat is the more important factor in rab, but how it acts has not yet been demonstrated." Was this wrote surcaustic?

In the seed bed, various substitutes are compared with cowdung rab, and safflower cake tops the list. No attempt is made to ascertain why safflower cake should be better than any other nitrogenous manure. All we learn is :—"It will be seen that safflower cake gives as good yield as rab while others gave as good seedlings. The other substitutes are also useful." Yet these useful substitutes are not tried in the same manner on field areas that receive plants started on unrabed plots. Of the seven experiments in this respect not one returned as much grain as the untreated plot. Cowdung ploughed in gave a very low return in the previous year, the duplicate plots showing harvests of 553 and 973 lbs. grain respectively, and safflower, which this year is pronounced better than rabing with cowdung, returned 1,047 and 1,670 lbs. grain respectively in the duplicate plots in 1908.

Yet deductions appear to be made annually from the tabulated statements of the year, without the slightest reference to the pigeonholed returns of the previous experiments. It is true that in the remark column opposite safflower and in other parts of the same we find a note "divergencies in soil," but we should like to learn when these were ascertained and how, whether by analyses or the harvest, and if known before the trials began, why any experiments were attempted that were to form the subject of comparison with results from better soils. After the various comparisons made we have to rub our eyes on looking at page 2 of the last report to find if we are quite awake ; for, there it is distinctly stated that the answer to the question if rab is necessary reads that it has been pretty thoroughly settled. It was years ago, but not by the experiments of the

Department of Agriculture. The lines *that follow are* still more startling. We were under the impression that the meaning of the word rabing had been "pretty thoroughly settled," the more so as its definition is repeated year after year in the Annual Reports. But here it gets quite another meaning, viz., "that some preparatory treatment to the seed bed is required as in regions of heavy rainfall broadcasting is not possible." Lewis Carrol is delightful when he chooses, in the person of Humpty-Dumpty, to give words any meaning he pleases. The report of 1909 is equally entertaining in this respect.

On page 4 we have a new set of experiments to throw "further light on this perplexing question by trying certain substances that are known to have a beneficial action on soils under certain conditions aside from the supply of any manurial substance." Lime we know for its action on the soil, common salt is exceedingly useful to certain plants, but of charcoal we have not yet heard, though rose-growers use it at the roots of their plants especially when these are grown in pots. Its use has been suggested by us in many cases as a deodorizer where a rotation cannot be practised, as on tea and coffee plantations, and where fields suffer from the overconcentration of the effluvia from the roots, when the same crop, growing year after year on the same field, renders the soil sick. But we should be pleased indeed to learn that the theory had been proved correct by actual practice in the field, for millions of pounds sterling would thus be saved annually.

In endeavouring to ascertain the kaleidoscopic changes in the harvests from plots treated in a similar manner, we have had to study the numerous tables and again form tables of our own. The following illustrates more clearly than any amount of writing the difficulties that beset a student when he endeavours to draw any conclusion from the rabed and unrabed plots scattered through the reports. :—

—	HARVEST LBS. GRAIN.				
	1905	1906	1907	1908	1909
1. Cowdung Rab .	1420	1620	680 to 2110	1200 to 2693	..
2. ,, ,, ashes.	1430	1600	1100	757	507 to 1307
3. Safflower ..	1730	1333	1344	1453	1447
4. No Rab ..	1410	400	nil to 480	..	720
5. Land heated ..	1700	1380	720	1587	507 to 1307
6. Earth pulverized ..	1310	980	440	982	533
7. Outside ashes ..	1230	880	788	..	693
8. Poudrette ..	1420	1320	1480	..	..
9. Cowdung ploughed in ..	1320	1700	1420	973	1173
10. Ain Rab ..	1450	1240	1440	1312	..
11. Ashes of Ain Rab ..	1720	1400	1440	..	..
12. Mixed branches rab.	1440	1120	1160	..	..
13. Ashes of branches rab ..	..	..	808	907	1307

And from this table we are to make the remarkable deduction that rab is necessary and at the same time cannot be necessary since we may have substitutes for it.

The difficulties arising from these figures are not lessened when we make up tables of (1) the cost of raising seedlings, (2) the cost of cultivation.

Statement showing cost of raising seedlings (in Rupees only).

—	1905	1906	1907	1908	1909
	RS.	RS.	RS.	RS.	RS.
1. Leaf rab ..	14	12	18	..	..
2. Ain rab ..	23	10	28	33	..
3. Cowdung ..	52	20	18	27	..
4. Grass ..	9	12	10	..	..
5. Mixed branches ..	39	10	22	26	46
6. Ashes of leaf rab ..	18	13	..	..	..
7. ,, cowdung ..	63	21	30	..	..
8. Cowdung ploughed in	54	25	15	16	..
9. Ashes of Ain rab ..	58	11	33	..	..
10. Land heated ..	40	17	37	70	130
11. No rab ..	4	6	3	..	9
13. Fish ..	54	70	101	..	..
14. Sheep folded ..	19	23	23	..	..
15. Poudrette ..	28	30	20	..	..
16. Safflower cake ..	42	35	25	44	20
17. Nitre ..	11	9	157	..	..
18. Cotton seed after plantation ..	4	2	..	..	..
19. Safflower ,, ..	3	2	42	..	..
22. Cowdung ,, ..	3	2	16	..	..
23. Earth pulverized ..	4	4	..	2	35
24. Ashes of mixed branches ..	36	11	24	31	37

Total cost of cultivation.

—	1905	1906	1907	1908	1909
	RS.	RS.	RS.	RS.	RS.
1. Leaf rab ..	39	27	34	..	..
2. Ain rab ..	48	25	47	55	..
3. Cowdung rab ..	76	35	35	50	33
4. Grass rab ..	34	27	26	..	..
5. Mixed branches rab ..	64	27	38	64	46
6 Ashes of leaf rab ..	43	28	..	..	..
7. ,, cowdung ..	87	36	51	..	..
8. Cowdung ploughed in ..	79	44	36	45	15
9. Ashes of Ain rab ..	83	26	52	..	..
10. Land heated ..	64	17	57	96	133
11. No rab ..	29	18	10	..	9
13. Fish ..	79	84	123	..	..
14. Sheep folded ..	44	38	40	..	..
15. Poudrette ..	53	44	39	..	..
16. Safflower cake ..	67	50	42	60	20
17. Nitre ..	36	21	181	..	18
18. Cotton seed after transplantation ..	39	25	..	..	..
23. Earth pulverized ..	28	16	30	28	35
24. Ashes of mixed branches ..	60	28	41	56	37

We expected variations of one thing at a time in the various similar plots, but we cannot but be surprised to see the number of simultaneous variations in the course of the experiments, the duplicate plots being often treated differently, so that nothing but varying results must follow. After reviewing the work done in these rabing experiments we needs must ask :—" Is this Science ?"

We started with the question " What does the efficiency of rab depend upon ?" and the Reports before us give no answer. We have yet to learn (1) Is it from the heating of the soil alone ? We are inclined to think not.

This also raises the question of the amount of heat required.

(2) The question as to what rabs are most beneficial has not yet received a definite reply based upon the trials before us. No doubt cowdung rabing is the best: whether on account of the more gradual heating or perhaps on account of the smell generated driving away the effects of the overconcentration of effluvia in the soil, who can tell?

If it is a question merely of chemical analysis Pusa ought to answer it without delay.

(3) The third query still remains a puzzle the more so as the term substitute is not defined. We know from practical experience that rice is grown without rabing, manured in many ways, and not treated at all, but if we wish to ascertain what returns the best harvest at the least expense, without harming the soil, we are inclined to follow the practice of the peasants notwithstanding the hopeless indecision in which these experiments leave us.

(4) The fourth question receives its reply the moment we know how to answer No. 3. If rabing is *necessary* (and even this word seems to require defining if we are to judge from the reports) no after-treatment will secure the same effects as rab.

We are not much enlightened on this point from the records of the years 1905 to 1909.

Throughout these experiments there is only one case in which a complete manure was used, but on what principle the quantities of the ingredients were chosen cannot be ascertained. A similar complete manure was employed on the field following cowdung rab on the seed bed, but we are not told what the component parts were, nor the quantities used of each.

Whatever experiments may be conducted in future, an end must be put to the senseless waste in raising seedlings.

The agricultural student rushes to the study of so interesting a puzzle, goes thoroughly into the maze of *contradictory results* from extraordinary experiments, and *emerges not a whit the* wiser, but certainly astounded at what is placed before him as a scientific study of a most important subject.

Another point that to agricultural reformers is a veritable red rag to a bull is the Indian plough. On this subject Mr. C. B. Clarke says :— "A favourite proposal is to give the Bengali an English plough, which shall go deeper than the native cultivator's and bring up fresh soil. I pass by the practical difficulty that, in none of the terraced fields and in none of the small fields, without a revolution in boundaries and customs, could such a plough be used. The plough is the most perfect implement yet devised for setting in creeping grasses, as couch; it cuts the creeping rhisome into convenient lengths and by the turn-over buries the fragments deep.......... Now, in India, we have not one or two, but many creeping grasses to contend with. The safety of the Bengali cultivator is that he has a hardpan, impervious to creeping grasses, which his plough travels upon, but never has broken. He gets the creeping grasses well out of the top 4—6 inches of his soil and has a full crop on his shallow tilth if the water is right. I may add that, if a Benga field was ploughed with an English plough just before dibbling, I doubt whether the rice would get a firm enough hold. ....I concluded my first (1868) paper on rice by saying that I did not think we had much to teach the Bengalis in rice-growing, and this statement did not, I fear, conduce to the popularity of that paper."

Mr. Clarke's statement is identical with that of Dr. Voelcker, when he referred to Indian agriculture in general, and every one who has spent some time in studying the Indian peasant's system of agriculture, considering the means at the raiyat's disposal, must agree that he is perhaps the best farmer in the world. Every unprejudiced student will be inclined to agree with Mr. Clarke in his view "that rice is the very last crop on which we should attempt to give the Bengali instruction." What the native of India wants is not instruction in tillage. He cannot obtain a sufficient supply of natural manures, and he must have before his eyes experiments with artificial fertilizers.

It must be explained to him that the plant takes certain substances from the soil and these can be returned to the land by the nitrate of potash, oilcakes and bone, he can obtain in India and from potash salts which unfortunately are not obtainable in the country but can be supplied by Germany, the source from which the rest of the civilized world procures it in inexhaustible quantities.

Professor Church's analysis of cleaned rice is as follows :—

Water	...	12·8	Oil	...	0·6
Albumenoids	...	7·3	Fibre	...	0·4
Starch	...	78·3	Ash	...	0·6

Of the ash, 0·065 is potash and 0·284 phosphoric acid. Of course more potash will be found in the husk and a great deal in the straw.

According to Payen's analysis of dried rice, it contains :—

Nitrogenous matter	...	7·55
Carbohydrates	...	90·75
Fat	...	0·8
Mineral matter	...	0·9

We see the very great quantity of carbohydrates in the grain and know how necessary potash is to produce these, and judging from the straw of other cereals which take from 55 lbs. of potash per acre in the case of wheat and 170 lbs. in the case of maize or Indian corn, we can judge that a fair supply of potash will greatly strengthen the standing crop and the phosphoric acid with the help of nitrogen will produce a plentiful supply of grain. Resembling the potato in its analysis, it is evident the use of potash in the paddy fields will prove beneficial and pay the raïyat for its use.

The addition of 1 to 1½ cwt. of bone and 1½ cwt. kainit to the ordinary 4 or 5 tons of cattle manure on well-cultivated wet lands has produced bumper crops in Southern India, and on dry lands a mixture of 1 cwt. bone and 1 cwt. kainit has proved equally successful and astonished the surrounding farmers by the weight and the excellence of the crops.

Where cattle manure cannot be obtained

3 to 5 cwts. of ground nut or castor cake meal
1 cwt. of bone
1 to 2 cwts. of kainit

should be employed, carefully mixed, and spread evenly over the field, after the grasses have rotted, and the return will be so great as not merely to pay for the cost of the manures, but there will be an extra profit in the first harvest, and, where ragi or a similar crop immediately follows, no further manuring will be required to secure another splendid return. When the day arrives that paddy and other cereals are manured all over India a great deal more will be obtained per acre than the one extra bushel that will pay the country's taxes.

COTTON.

There is nothing new under the sun. The trite old saying is brought forcibly to mind in perusing Walton's "Short History of Cotton, its Culture, Trade and Manufacture in the Belgaum and Kaladgi Districts of the Bombay Presidency," written for the "Bombay Gazetteer" and printed at the Government Press in 1880.

As far back as 1820 the Statistical Reporter to Government recommended the cultivation of Bourbon cotton which was then actually being grown to a small extent. In 1828, Lord Ellenborough represented to the East India Company the importance of improving the cotton in the Southern Mahratta country, and in 1829, experiments were conducted by Dr. Lush to obtain (1) a better variety of cotton, (2) to introduce better systems of cultivation, (3) improvements in ginning and preparing the lint for the European markets.

It is not surprising that the report was a record of failure.

In 1835, a fresh supply of seeds of various exotic varieties was imported, and in 1840, three American Planters arrived in Bombay to superintend the work of cotton improvement. They and their successors tried hard to induce the kunbis to make experiments with these exotics. The results were far from encouraging. Against a yield of 148 lbs. of Nurmah cleaned cotton per acre, Georgia produced 88 lbs., Sea Island 57 lbs., and Bourbon 36 lbs. on a small area. In 1848-49, the raiyats stated that their New Orleans plants were "dead sticks," and would not yield 1 lb. per acre.

The Dharwar area, more suitable perhaps for growing this particular cotton, showed results still visible in the "sawgin" as the Dharwar-American cotton is called to the present day. But in Belgaum, the succession of failures and steady decline of acreage of exotic cotton is marked from 1840 to 1860.

While these experiments were in progress, we learn "that the Manchester Commerical Association had been repeatedly urging on the Directors of the Honorable East India Company their view regarding the improvement of cotton in India, and the Honorable Court had sent their representations out to the Bombay Government from time to time for action to be taken on the advice proffered. One subject that the Association persistently urged, was earlier sowing, and Mr. Channing did his best, as he too then agreed with the Manchester view, to get the raiyats to sow sooner; he, however, failed to get them to agree, and subsequent long and large experience has amply proved that the farmer knew what he was about, and that his time for cotton-planting in the Kaladgi and Belgaum country was right, and that the Manchester Commercial Association and Mr. Channing was wrong, etc."

The over-zealous advocates of improvement in Indian Agriculture fall into a very common error by supposing that what is good for the West is equally good for India. When we think of the Duke of Buckingham's idea of draining the paddy fields, we fancy the boundary of absurdity has been reached, but the volume before us points to advice more glaringly absurd. Painful as it is to stumble along the pages of this remarkably tiresome work, the *ipsissima verba* of the author will demonstrate only too clearly the absurd lengths to which reformers will go in their zeal for change. The American Planters appeared to share the views of the Manchester Commercial Association, and the remarks on this subject on page 98 are worth perusal. They run :—

"Another question which was very often urged by the American Planters, and which has been still more strongly recommended by many outsiders since, is 'early sowing': it is being repeatedly represented that the Belgaum and Kaladgi farmer does not plant his cotton soon enough, and that consequently his growing crop has many more trying circumstances of climate to contend against, than if he put the seed in sooner; as a matter of fact no fixed rules on this subject can possibly be made, the correct time for sowing in each district being so entirely regulated by the rainfall of that locality; no cotton seed can be successfully sown until a certain quantity of rain has fallen, and has brought the soil into its proper condition for germinating the seed; this essential condition of the earth is much better understood by the farmer than by any foreigner."

Mr. Walton evidently knew more about the wisdom of the native farmer in choosing his sowing time than all the Americans and "outsiders", who endeavoured to give what they considered beneficial advice to the backward Indian kunbi.

Science is admirable and its dictates should be followed; but true agricultural science depends, to a great extent, on experience, and the native raiyat has behind him the experience of countless ages.

In this volume we find the soundest advice to Government, couched often in the bluntest form, emanating, not from what now would be called the Department of Agriculture, but from those who knew the people and their ways, and made a lifelong study of these whose welfare had been entrusted to them, viz., the Civil Servants of the country. In reply to the 'early sowers' Mr. Seton-Kerr, Collector of Bombay, wrote in 1850:—"Early planting from the middle of April to the end of May, I need hardly tell you, has never been tried; those months, in the cotton plains, are perhaps the hottest of the year, and the seed might as well be put into an oven as into the ground at that time." But the reformers were not satisfied. The Bombay Chamber of Commerce advised people to sow cotton in May and November, and it was in reply to this advertisement that in 1860 Mr. Mansfield, who had long known the Kanarese country, told Government that all persons who followed the advice given above would lose both their seed and their labour, as "the soil in the month of May is very like cinders heated to a temperature of one hundred and fifty degrees; the soil continues in this heated state till the middle or end of June, when the seed if not turned into cinders or deprived of all germinating power, is reduced to a state of rottenness by the torrents of rain at the first burst of the monsoon: if sowing, again, is delayed till November, the cotton has not time to ripen before the fierce heat of the sun forces the bolls to open prematurely, etc."

Similar wise advice reaches the ears of the astounded raiyat at the present day, but seldom does he hear of what he really wants, and that is a manure that will take the place of cowdung, which he cannot get in sufficient quantities. It is rather startling to find in the volume before us the following lines:—"Manure is freely used, but it is not put on the land when cotton is to be sown. The raiyat says that fresh manure heats the soil too much for this crop, and it is therefore put on in the year preceding that in which he intends to plant cotton, the quantity then used being from three to six cartloads an acre; the ordinary village manure consists of the dung and litter of cattle, decayed vegetable matter, fallen leaves, sweepings, ashes, etc., of houses; all these are carefully gathered and added to the raiyat's manure heap, and by the time it is ready to be carted out, it is in a pulverised state and readily amalgamates with the soil."

How 3 or 4 cartloads of such manure can be said to be a free use of manures for two crops, it is difficult to understand; yet, throughout the numberless cotton experiments, no hint is given of an attempt at improvement in fertilizing either with natural or artificial manures.

Another very weak point in these experiments, and one on which too much stress cannot be laid, was already then discovered and brought to the notice of Government. "A leading officer of Government in the Bombay Southern Districts, Mr. Townshend, who took much interest in the Belgaum experiments, expressed his disapproval of attempting to improve cultivation by Government Farms, the weak part of the arrangement being, in Mr. Townshend's opinion, that it merely showed the people that a certain plant could be grown in the country, but did not let them know what it cost to produce it, and that Government Farms were managed on a scale of expense that it was useless to expect that the raiyat would emulate, and that unless you could show the Indian farmer (and of this Mr. Townshend saw no hope) that it would pay him to take up a culture that was successfully carried out under Government management, the large outlay expended on the experimental farms, was only so much money thrown away." Without going as far as Mr. Townshend in his wholesale condemnation of Government Farms, it must be conceded that there is a great deal of truth in his statements, and that it is necessary at the present day to point out to Government the limitations of these institutions as it was in Mr. Townshend's time. Whether the present authorities would, like Lord Falkland, agree with Mr. Townshend's views, and style the Commissioner's representation "a very sensible letter," is doubtful, though the arguments are as forcible to-day and as difficult to refute as in the days gone by.

And here we may mention that the object of instituting demonstration farms does not appear to be remembered in India. Even those who conduct them seem to confound the end in view with that of experimental stations. The latter are to be found all over Europe, sometimes combined with practical field work to show that the results of patient observation and study can be made to pay the farmer. But experimental work is meant for Colleges and Institutes whose aim is to settle fundamental principles of which they are in search. This means that men specially selected for such investigations patiently amass facts and figures for years, from which to deduce later on general rules applicable to the science of farming. Demonstration farms, however, merely put into practice what these experimental farms have discovered after toilsome research, and, at the same time, make detailed investigations suited to the particular localities in which they are situated.

They must be practical farms, where cultivators are shown not merely what crops are grown, but principally how these are made to pay.

A famous American agriculturist, speaking on the point last year, said that the demonstration farm that did not pay should be closed at once.

A great many will agree with his opinion.

The Manchester Chamber of Commerce in 1849 presented "a long memorial to Parliament urging on the Imperial Legislature that an inquiry should be made under the orders and at the expense of the British Government, into the causes of the unsatisfactory condition of the cotton trade and the measures that should be adopted to increase and improve the same." The House refused the inquiry and the Chamber sent out a special agent of their own in 1850. Of course, the agent knew more about India and the cotton-growing districts than the men who lived on the spot, and gave the greater part of their lives to the study of the people and their wants. The reply of the then Collector, Mr. Havelock, to Mr. A. Mackay, Special Commissioner of the Manchester Chamber of Commerce, is interesting reading even in 1911. Mr. Havelock made some very apposite remarks on the adverse criticisms that had been made by Mr. Mackay, criticisms which were so common from other writers with an imperfect knowledge of their subject, on the system of native agriculture, and truthfully added that if Europeans came to cultivate farms in India, experience would soon make them discard many of their ideas in favour of local methods. The Collector's remarks were based on not only what he himself had observed but also on conversations he had had with some of the American Planters who had been sent specially to India to improve cotton culture, and these latter gentlemen frankly admitted that there was much in the native system of farming to admire, and that it was well adapted to the circumstances of India.

The truth of this has been repeatedly shown since. In fact, the only experiments that have proved successful are those in which the ground-work has been on the native plan, developed and improved by European knowledge, zeal, and energy.

It is wonderful how history repeats itself. The present time is not the first in which the weighty question was argued as to whether it would pay Europeans to grow cotton in India. The question is a vexed one. It is quite possible that, following the native methods, but using a sufficiency of cattle manure and concentrated fertilizers, the crop may be so far increased as to pay well, and that a good selection of seed, followed by careful picking, ginning and packing, may so increase the outturn and the value of cotton as to make such agriculture in India a profitable concern, but a study of former attempts and failures would be an absolutely necessary prologue to the embarkation on such a venture. "During the time that Sir J. R. Carnac was Governor of Bombay," says Walton, "the question was started as to whether cotton culture could be carried out on a large and successful scale by Europeans in India; the subject was much discussed and His Excellency records the following opinion:—"Cotton culture holds out no inducement for any private person, who knows what he is about, to engage his capital in any speculation on a large scale; all cotton and experimental establishments have clearly and repeatedly shown that Europeans could never compete in economy, or in gaining compensating results, with the farming of the raiyats; generally speaking all work in the Indian farmer's holding is done by him and his family, and their labour is given with all the self-interest and the constancy of personal concern: it is quite as impossible to compete with this, by hired labour, as it is for the European himself to do much of the work of a farm under the Indian sun, and he winds up with the far from optimistic view of Mr. Cassels that "hired labour in India, so far as the labourer is concerned, is a contract to do as little work as possible for the highest possible wages, and colonization for the purpose of actual cultivation is a hopeless undertaking."

Yet even while the above was being written there were Europeans making native Jaghirs pay under their management, and at the present day in Southern India, paddy fields appear to be capable of giving Europeans a fair living.

Nowhere within the pages of this treatise do we find any attempt made at practical farming, and those engaged in the work of endeavouring to improve cotton culture appear to have accepted the 60 to 80 lb. crop against the American 200 to 300 lb. of lint as one of the decrees of fate. Were the question now taken up, the possibility of making cotton culture pay might have another answer. Since those days, it is true, the Agricultural Department has run wildly to the other extreme, and one's hair almost stands on end to find the employment of 40 tons of cattle manure, 30 tons of poudrette, or 4 tons of superphosphate, on an acre, in a land where cattle manure is so scarce, municipalities in their infancy, and the price of concentrated fertilizers absolutely prohibitive, when used in quantities unheard of in any other part of the world.

There are other subjects with regard to cotton that occupied the minds of men in those days so bent upon doing good to the unfortunate peasant, as far as lay in their power. The question of irrigation for cotton had their attention, and it is one that is now, or was lately, *being studied* in Sind.

It was the Court of Directors who started this enquiry in 1855, and the consensus of opinion appears to have been that, on regur (black soil) and on red, irrigation invariably resulted in failure or loss. In 1858, the matter was referred to the Indian Agricultural and Horticultural Society, and their verdict was that "much must depend on the climate and the soil where the culture is carried out; in places where the soil is sandy and light, frequent irrigation will probably be found necessary for the successful growth of the plant; in other places a moderate degree of moisture only, while again in others, it may not be at all necessary, but on the contrary prove hurtful to the plants."

Amongst the remarks sent to Government on this point, one Deputy Commissioner says:—"Were artificial irrigation advantageous, there is little doubt that we should find cotton among the garden products as the crop is a very valuable one, and the people are good practical agriculturists." This, of course, refers to cotton soils so called. Colonel Taylor, a recognised authority, says, however:—"If cotton was ever planted on shallow, stony or sandy soils, during the six months after October, a couple of waterings or at the most three, might benefit the plants, but that after that it would be hurtful with every description of cotton and in every kind of soil and in almost any land watering had the effect of weakening the fibre, and, keeping the plants greener than nature intended, invited the attacks of insects." Colonel Taylor's views as regards shallow, stony, and sandy soils have received support from all parts of India and from many eminent officers, amongst whom may be named Sir D. McLeod and Sir R. Temple, both of whom, when they wrote, were serving in the Punjab.

Now that irrigation is being introduced extensively into the Deccan, that companies have lately been formed for gain by cotton culture, and that Government are pushing the growth of exotics in Sind, it may be worth the while of those interested to look up the old musty records that give the results of the lifelong study of men, who certainly cannot be looked upon as fossils, men, who had the interests of the country as much at heart as those of the present day, and in studying their subject never refused to listen to the raiyat, whose practical experience is always worth noting. It is in reference to these records that the following lines occur, which look like a severe critique on the doings of the present day. "Useful and valuable as many cotton experiments have been it is much to be regretted that more use is not made of the valuable experience gained, in reading the voluminous and interesting records of these operations in not only the Belgaum and Kaladgi country but throughout India generally. It is a pity to see how often the commonest laws and principles of nature have been ignorantly set on one side and disregarded, and also how very often no knowledge appears to be retained—at any rate made use of, by experience; one experimenter has gone on after another in the same groove, has committed the same mistakes, has got the same results and announced them as new, though if care had been taken to inquire what had been done before and examine records, the new zealous experimenter would have found that all he was doing had been repeatedly done before and that his experience was only a repetition of that of his predecessors; a timely inquiry into the results, recorded in every Collector's Kacheri, would have shown him all this and have probably guided him, so that he would have avoided the mistakes that had been made before his time and have adopted plans that would have been more in accordance with the circumstances of the district where he was carrying out his experiments and he might have thus been able to record a success, instead of adding another to the many failures and disappointments that had gone before."

It has been often said, and cannot be too frequently repeated, that the proper method of improving the cotton of the country has not yet been attempted. It is useless to get the raiyat to try experiments. Guarantee him against loss and show him that artificial fertilizers can take the place of natural manures so scarce in the country; prove to him that his indigenous crop can be greatly increased; then, if you wish it, show him the benefit of selected seeds; and, finally, when his mind is prepared for it from the benefits he has seen in the new manures, suggest small trials of exotic cottons. Till this procedure is adopted, one failure throws back any chance of improvement for half a century. It is simply astonishing that the more gradual and sensible way of improving cotton culture has not hitherto been given a fair trial.

From the following report we can judge that more than one year's trial is necessary before advising the raiyat to change the variety of crop he has been accustomed to grow. It will also be seen that the peasant is alive to his own interests and makes a change in the seed and variety of cottons grown when he thinks it necessary or useful.

Mr. T. Middleton, B. Sc. (then Professor of Agriculture, Baroda College), as far back as 1895, writing in the Agricultural Ledger, No. 8 of that year, says :—
" There are certain cottons for which the selection of seed seems the only practicable method of improvement; to cross them with other kinds would probably result in destruction of their valued properties. Unfortunately, selection of seed, although a certain method of improvement, is a process which only yields appreciable results after a more or less lengthy term of years; and, unless selection is maintained, the crop will soon deteriorate to the same level. It is on this account that selection of seed which is almost universal in gardens, is comparatively rare on farms. The farmer chooses good, sound and healthy seed but he seldom finds that the careful selection which repays the gardener is suited to his business. The raiyat knows that the most carefully picked seed is as nothing to the crop as compared with clean soil, or manure, or a good season, and although he does select jowari I am afraid it would be difficult to get him to take the small amount of trouble that the selection of the best cotton seed would render necessary. At the same time there is not much danger that Varadi or any other form of Bengals will invade the cotton plains of Broach and Surat, for the cultivators know the value of their plants too well; they do not wish an early variety, and if a stranger appear they will remove it, when weeding. Even if the ginners purchased ' Bengals' and mixed the seed in ginning the cotton, I do not think that the

Broach crop would become mixed; for, if the practice became general at the gins, the cultivators would then begin to select their own seed for sowing. In the Districts where Goghari is grown the best cultivators do select their seed, otherwise they would get it from the gins mixed with deshi. They will take the trouble to select seed to keep it pure but I question whether they will take the trouble to do so for the improvement of an unmixed variety."

No better testimonial can be given to the Indian raiyat than this, as to his careful attention to the selection of pure seed when it pays him. We can scarcely expect of him what we do not demand or expect of the European farmer, and, if Government find it the labour of years to show the smallest success in improving unmixed varieties, it is surely a little too much to expect from the kunbi.

Good cultivation and manuring are the best ways at his command and he uses these according to his means and knowledge. Even business men are in no hurry to undertake the selections mentioned, on the mere chance of some day having a better return. We cannot advise the peasant to undertake extra labour for a problematical small gain.

All over the country we see changes made in the sort of cotton grown, and though Mr. Middleton points out the causes he can scarcely blame the peasant for the fact. He says:—"The raiyat's sole object is to get as many rupees for his crop as he can, and he cannot be expected to cultivate a worn out and delicate plant, however good the staple, in preference to a hardy species that produces a more certain yield. The true remedy for his so-called ignorant preference for short-stapled cotton, is to provide a more paying long-stapled variety."

But this is just the crux. If Government would undertake to grow cotton on a commercial scale, hybridization might be tried to any extent, and paying results would receive the intelligent appreciation of the farmers around.

In speaking of acclimatization, he continues:—"Whilst there is little that can be done in the acclimatizing of indigenous growths, there is a certain amount of scope for the introduction of foreign cottons. Such numberless attempts have been made to raise American varieties and such numberless failures have been reported, that one is apt to forget that there have been successes. The most notable of these was in Dharwar, but the exotic cotton has deteriorated there and is now of poor quality. I do not know the district but I cannot help thinking that the cause of deterioration is mainly neglect, and that, if the stock had been as carefully nursed in India as it is in America, there would have been no complaints of the Dharwar cotton of to-day.

Yes, the point to be considered is careful nursing. When we compare the sums spent on manures in America we may well speak of careful nursing, and lose all thought of wondering at the difference in yield of the two countries.

If this variety could not stand a heavy rainfall when young, who is to guarantee the raiyat against loss in trying to grow it? Though it was successful in Dharwar it was a hopeless failure in the adjoining Kaladgi country. It is right and proper for Government and Scientists to give time, attention, and money to the study of exotics, but the Indian farmer cannot afford it, and his so-called ignorance is nothing but shrewd mocmon sense. He has very good reasons for growing a short staple crop, that, as a rule, pays him in years of ordinary rainfall, and he does not think it wise to gamble on long staple species where climate, soil, and, worst of all, rain, may prove so many chances against him.

In this connection the following interesting note from Mr. Jaysukhrai Mangalji Vaishnav, D. Ag. Assistant Director of Agriculture, Junagadh, is worth attention, and instructions have been issued to study the subject of rotation to which reference is made.

NOTE ON THE INDIGENOUS COTTONS GROWN IN THE STATE.

The variety of cotton, which has replaced Kala and Lalio in nearly the whole State except in that portion called the Ghed, is Mathio, which is most probably the same as Kanio.

The word 'Mathio,' is probably derived from 'Math', a species of pulse (phaseolus aconitifolius) the leaves of which closely resemble the cotton.

It is also called 'Satio' from 'Sati,' a thin cane; as the plant grows up straight without sending out branches of any length. Its other name is 'Divalio' as it ripens at the time of the Divali holidays.

A variety of this cotton has white flowers, and hence receives the name of 'Dholifuli' or the white flower.

As the cotton, after flowering for the first time, has other flowers fortnightly during the season, it is also called 'Arthio' from 'Aradi' which means half, and the name implies that it flowers every half month.

These various names would lead one to think that many varieties were grown, but it is one and the same species under different names in various mahals.

About Keshod it is called 'Afar', from 'a' not and 'far' to change—i.e., a sure crop is expected.

Kala or Dhumbad is a deshi Kapas, which, as far as I know, is the old Dhollera deteriorated. The bolls of this plant do not open and this led to a great industry amongst those who ginned by hand in the days before machinery; for the ginners were those who drew the lint from the capsules.

'Lalio,' a name derived probably from the fact that the cotton appears to pour out from the boll, is now very scarce.

Attempts will be made to put a larger area under this species.

'Kadayo' is a variety of American cotton, formerly the principal crop in the Gir districts. It has a somewhat broader and less divided leaf with black seeds.

These are however distinguishable from the Kala in that they have no velvet on them. Kala and Kadayo require heavy rains. Kala ripens late; Kadayo, much sooner. The after effects on the succeeding crops are quite different. While Kala or Dhumbad and Lalio take a longer time to ripen and are harvested about February—March, the Mathio or Kanyo Kapas is ready for gathering after Divali. Hence, the absence of late rains diminishes the yield of the former but has little effect on the latter.

Notwithstanding the difference in price this fact has led the cultivators to introduce the latter variety.

The majority of farmers, especially those to the South of Bagadu and Ajat, are now inclined to revert once more to the cultivation of Kala as the yield from the Kanyo is diminishing year by year and the cereal crops that follow the latter in rotation, especially bajro, are very poor, that is to say, the halms grow well, but little grain is produced, while such was not the case after Kala or Lalio.

As the opinion of the Khedouts is diametrically opposite in different mahals the important subject of rotation requires careful study by this department."

Mr. Mollison, M.R.A.C., then Superintendent of Farms, Bombay Presidency, in his Annual Report of the Government Farm at Poona, for the year ending 31st March, 1894, writes :—" Besides the effect of hybridization, there are other controlling influences which tend to make the cotton of one district superior or inferior to that of another. Soil, climate, good or bad cultivation, each exercises a material effect. At the same time I am convinced that any attempt to supplant an inferior variety, indigenous to a district, by the introduction of a superior variety, indigenous to another district, would probably fail. The cotton soils of Khandesh and Surat are not unlike. The cultivation is about equal in each district. A discredited short-stapled variety (Varadi) is the chief crop of Khandesh ; whilst the cotton of Surat is one of the finest long-stapled varieties cultivated in India. I believe that neither of these cottons could with advantage be interchanged between districts. The results obtained in growing Surat cotton (Broach Deshi) on the

Poona Farm exemplify how stubbornly cotton lends itself to any change. The out-turn of lint was quite satisfactory; the length of staple also was good; but the fibre compared with that grown in Surat was coarse and harsh."

Some further light is thrown upon the subject in the Annual Report of the Deputy Director of Agriculture for the year ending 31st March, 1904. Two paragraphs require the careful attention of all interested in the improvement of cotton. They run :—"Many attempts have from time to time been made in this connection, but in no case can success be said to have been attained. The case of Dharwar (or saw-ginned) American, introduced from America about A. D. 1820 is, though still grown as a field crop, no exception, since the quality of the fibre has so deteriorated as to command in the market a price no higher than that of the local indigenous variety (Kumpta). It may be of interest, in view of so many applications received by me for seed of foreign varieties, to point out as far as possible the cause or causes of the failures: one cause is undoubtedly that in most cases the introduced variety has received the same treatment in cultivation as the indigenous variety grown in the district into which the introduction has taken place. It must be said, however, that this factor was probably not the predominant one in causing failure.

Without doubt the chief cause of failure is and always has been the difference in the amount or distribution of the rainfall in the regions from and to which, respectively, the introduction took place. Taking the case of introduced American varieties we know that in America the crop has been grown (without irrigation) for at least six months of its period of growth under a uniform rainfall of 4 to 6 inches per month. In Egypt practically the same amount of water is supplied in the form of two waterings per month, given from irrigation canals. It cannot therefore be expected that crops from these countries would succeed, even were all other conditions the same, in a district, such as that where the whole of the rainfall of the year (42 inches) falls in about 3½ months. It is worthy of note that the only district of this Presidency (Dharwar), where the American variety has been acclimatized at all is that in which the rainfall approaches more nearly in distribution to that of the cotton belt of America :—Dharwar has a rainfall of 33 inches distributed fairly evenly over 6½ months (April to October), etc."

At Ranipettai, N. Arcot District, where, owing to the sandy nature of the soil watering was a necessity, Metaffifi produced seed cotton in the plot experiments at the rate of 1000 lbs. per acre, and tree cottons, such as Thomatis, reached a height of six feet in well-branched bushes by the end of six months, flowering well and producing bolls. They were attacked by red bug, which are easy to get rid of when they first appear. If a little kerosine oil is placed in a can, and the branches tapped gently, the bugs fall into the oil and are killed. This done in the first week of their appearance puts an end to the pest.

In the village of Khadia, eight milesfrom Junagadh, in Kathiawar, watered Metaffifi produced over 1000 lbs. of seed cotton per acre on a sandy loam.

So far Egyptian cotton has not been tried on a commercial scale. The results of the experiments in Sind are not encouraging. In the Annual Report of the

Agricultural Department, the stations outside Mirpurkhas and Doulatpur report (page 4 'Egyptian cotton on the Jamrao'):—"In 1908, 4,000 acres of Egyptian cotton were sown in the Jamrao. It was mostly Abassi with some Mitaffifi in Singhor and Jamesabad. The crop on the whole was very poor. It could not be sown in proper time as the water-supply in the canal was deficient. It suffered much also in common with other crops from flooding in some districts. The cultivation too was poor and there was probably not more than 1,500 acres of cotton which could be said to be at all good. 4,000 maunds of cotton were sent to be disposed of at the auction at Mirpurkhas but owing to the quality of the cotton it had to be sold privately at Rs. 9 for Abassi and Rs. 6 for Mitaffifi per maund of 81 lbs."

The $1\frac{5}{27}$ to $1\frac{7}{9}$ D. obtained is far enough removed from the $5\frac{1}{2}$ D. per lb. and the Rs. 225 per acre of Egypt. Of this exotic the Director-General of Agriculture writes :—"If Egyptian cotton is introduced as an irrigated crop into the Bombay Presidency it must of necessity occupy land that is suitable for irrigation. The texture of the soil in a great measure determines this. On land suitable for irrigation with irrigation facilities, expensively cultivated and valuable crops now grow. Such crops under favourable conditions are taken in rapid succession, two at least per annum, the annual produce at a moderate estimate being worth Rs. 300 per acre and often a great deal more. The idea of growing Egyptian crops on the deep black cotton soils of Broach or Surat is impracticable, inasmuch as such land is unsuitable for irrigation. There are lighter soil areas in Dharwar and Khandesh now growing cotton as a staple crop which with facilities for irrigation and a sufficient supply of manure could be irrigated to advantage. The cultivation of Egyptian cotton on such areas would no doubt be taken up by ordinary cultivators (*a*) if it was certain that the cultivation of this exotic was free from risk, (*b*) if the out-turn under favourable conditions was worth as much as or more than that of such ordinary garden crops, as onions, ginger, turmeric, sweet potatoes, yams, etc."

But the old records had not been referred to, and the new rulers knew not Mollison and certainly did not heed his counsels. But, before troubling about exotic cotton, let us see if a paying crop can be obtained from indigenous cottons, when complete well-balanced fertilizers are used. If this can be done, the raiyat will soon follow the example given, and, in course of time, will see his way to try, on a small scale, experiments with exotics that may possibly pay him. No doubt the reports of what is obtainable from long-stapled cotton are tempting, and we do not wonder that trials were made to grow Egyptian cotton, when we find in the Report of the Director of Agriculture for 1897 :—" Mr. Tata points out in his pamphlet that the average out-turn of clean cotton per acre in the most favoured district, Broach, is not more than 100 lbs. per acre, estimated to be worth in English currency 3½ *d*. per lb. He estimates the average out-turn in Egypt to be 600 lbs. per acre and on account of the fine quality of the lint is held to be worth 5½ *d*. per lb. In Indian currency, at the present rate of exchange, the Egyptian out-turn is equivalent to Rs. 225 per acre."

It is a glorious outlook, and we may devoutly hope that some such profits will become general in India. But we must first know something more of climate, soil, rainfall, tillage, manures, etc., that will bring about this happy state of affairs. In the meantime a little attention to manuring may bring our indigenous harvests to figures not far removed from the Egyptian standard. But to accomplish this, fertilizing will have to be resorted to. You cannot expect to get everything for four annas. As a rule you will get only four annas' worth.

Rich as the soil of Egypt has become by the silt deposited from the overflow of the Nile during centuries, till the alluvium is anything between 55 and 400 ft. in depth, it has already been found that the canal system, allowing of the growth of crops all the year round, has so depleted the soil that artificial manuring must be resorted to.

That drainage on a larger scale must accompany irrigation is also only too clearly shown by the large tracts on the lowest part of the Delta being converted into swampy uncultivable salt marshes.

The yield of cotton per acre is going down rapidly whereas

in	1895—1897	the average yield was			500 lbs.	per acre.
,,	1898—1900	,,	,,	,,	450 ,,	,,
,,	1901—1903	,,	,,	,,	455 ,,	,,
,,	1904—1906	it was			385 ,,	,,

In 1907 the total yield was 315,000 tons or 1,764,000 bales of 400 lbs. each.

At this rate of deterioration if a check is not put to it the average will soon fall below America, and in a single lifetime perhaps sink to the level of an Indian cotton harvest.

The chief causes to which this is put down are:—

(1) Overcropping.

(2) *Deterioration in quality of seed.*

(3) *Insufficient drainage.*

(4) Want of Manuring.

The Americans have to spend money to make money, and they have the sense to do it. With good manuring and carefully selected seeds, well-cultivated areas have produced 500 to 800 lbs. of lint in the United States, though the average for the whole country is about 200 lbs. Resort is now had to heavy manuring to obtain good crops, and special fertilizers are used to haston maturity and thus shorten the growing season. It may be urged that our peasants are so poor that there is no question of purchasing fertilizers. If individually the task be found difficult, combination will soon enable them to obtain the help of Agricultural Banks, and if Italy appeared in as hopeless a condition of agricultural insolvency as the India of the present day, there is no reason why our raiyats should not imitate the action of the Italian peasants, who are now prosperous, and perhaps the best agriculturists in the world. Any way, small experiments can be tried in a number of villages, and if these prove successful, no further urging will be required to set the cultivators on the right road to increase returns from their cotton fields to a considerable extent.

To enable the raiyat to see what is done in the United States of America, the great cotton-producing country, an interesting report on the cost per lb. of lint to the American farmer is here reproduced. If there is a heavy return per acre, there is no slight expenditure; and in the matter of fertilizers the peasant here will scarcely believe it possible to obtain a profit when so much money is put into the soil before the seed has sprouted. But this alone will explain how the farmer of the United States can get a harvest that may not be considered anything very great in his country but would be a mine of wealth to our poor kunbis, whose wants are so few, and whose support costs so little.

According to the latest Government returns for the year 1909-1910 the acreage under cotton in India was 20,227,000 acres, and the estimated crop for an exceedingly good year 4,626,500 bales of 400 lbs. each, showing an exceptional return of 89·5 lbs. per acre. Against this an average of 198 lbs. as shown in the table of the cost of raising cotton on a number of American farms, points practically to the difference, not in climate, soil, tillage or labour, but to the want of manuring. Yet 198 lbs. is not a high average for the States, and there is no reason why, if fertilizers were used in India, the returns should not equal those of America. The gain here would of course be far greater, for the nitrate of potash, oilcakes, etc., are cheaper, and the cost of labour infinitely less. The kunbi will simply rub his eyes when he sees the cost of production across the Atlantic. It is doubtful if he will believe a word of it, but we merely mention well-established facts and figures in the following quotation from the "Times of India" of the 27th May, 1909, in the column 'Trade and Finance,' where the following article on the cost of producing cotton appears :—

"There has been a great deal of discussion of late in the United States about that important and always interesting question, what it costs to produce a pound of cotton. It is often said that the cost has increased enormously in recent years, and that a price of eleven to fifteen cents, (5·28 to 7·20 annas), per pound is necessary to remunerate the farmer. "Farm and Ranch," a paper published at Dallas, Texas, has been printing a voluminous correspondence on 'What it costs to produce cotton,' contributed by farmers, who have given actual figures and estimates based on their own experience. Such estimates, are, of course, likely to err, if at all, on the high side, and indeed some of the figures given have been so obviously exaggerated as to draw protests from other farmers. The whole correspondence in nine issues of the paper has been carefully analysed by Messrs. A Norden and Co., of New York, and excluding only a few letters which contained insufficient details, they have tabulated and averaged the figures contained in the remaining 45 letters, written by 37 farmers in Texas, four in Arkansas, three in Oklahoma, and one in Louisiana. The size of the plantations dealt with ranged from 1 to 100 acres, and the aggregate area was 1,153 acres. The results of this analysis are so interesting that they may be reproduced in detail."

Messrs. Norden say :—

"We have taken everything exactly as given, correcting only some obvious errors, and wherever some one detail was missing we have made full allowance, giving the producer the benefit of the doubt. To take up the items in detail · Preparation of the soil, planting the seed, and cultivation are exactly given ; the only feature to be noted in these items is the fact that in most of the examples practically none of this expense is really an actual cash outlay, but only an allowance of supposititious wages that the farmer makes to himself for the work done by himself, at rates varying from 1 to

3 dollars (Rs. 3 to 9) per day and averaging 1 dollar 70 cents (Rs. 5-4-0) per day. 'Rent' in most cases is figured at 4 dollars (Rs. 12) per acre, some paying only 3 dollars (Rs. 9), while others rent on shares of the produce, in which case it is considerably higher, contingent on the outturn of the crop.' Where rent is not mentioned, the farmer owning his own land, we have charged it at 4 dollars (Rs. 12) per acre. 'Wear and Tear' on stock and implements is only included by a few, but from these few we gather that 75 cents (Rs. 2-4-0) per acre would be a full allowance. To be more sure, one man included a three hundred dollar pair of mules and several hundred dollars worth of implements in his estimates of the cost of one crop of 50 acres, but such figuring is manifestly absurd, as the outfit would serve for at least five crops, possibly ten. We have figured on only five years' life on such property or 20 per cent. annual deterioration. Many have omitted to account for the seed, or have given the seed to the ginner to pay for the ginning. In these cases we have figured the seed at only 11 dollars (Rs. 33) per ton, charging in the ginning column and crediting in the seed column.

To arrive at the item 'Yield of lint per acre' whenever exact figures have not been given, or the result has been stated only in bales or in seed cotton, we have taken a most favourable basis, viz., one bale to three acres, which is rather less than the average 500 lbs. per bale, though Taxas cotton averages considerably higher, and the seed cotton to a third itself (lbs. 1,500 eseed cotton equals 1,000 lbs. seed and 00 lbs. lnit), though it will probably run 37 to 38 per cent. lint. The estimated net cost of production of one pound of lint in these examples ranges from 1·4 cents per lb. to 22·3 cents per lb. (8·046 pies to 10·704 annas), but neither of these extreme results should be taken as a basis. The former was the result of an exceptional yield— 658 lbs. of lint cotton per acre and accounting for the seed at 50 cents per bushel, while the latter was the result of a crop failure, 65 lbs. of lint per acre. In the following table we have separated the reports as follows :—

	Net cost of production.
General average of 46 reports ...	7·73 cents per lb.= 3 as. 8½ pies.
Average of 7 exceptionally favourable reports, figuring below 5 cents. per lb.	4·25 cents per lb.=2 as. 0½ pies.
Average of 32 reports figuring between 5 cents and 9 cents ...	6·82 cents per lb.= 3 as. 3 pies.
Average of 6 exceptionally unfavourable reports averaging over 9 cents.	16·04 cents per lb.= 7 as. 8 pies.

—	General average of 46 estimates.	Average of 7 estimates reporting cost below 5 cents.	Average of 32 estimates reporting cost between 5 & 9 cents.	Average of 6 estimates reporting cost over 9 cents.
Acres reported on ..	1153	31½	880½	241
	Dollars.	per	Acre.	
Preparation of soil ..	1·62	1·34	1·59	1·78
Planting and seeds ..	·65	·62	·67	·62
Cultivation to maturity..	3·43	4·09	2·78	5·70
Rent ..	4·13	3·46	4·18	4·01
Wear and Tear ..	·75	·75	·75	·75
Total cost to bring one acre to maturity ..	10·58	10·26	9·97	12·86

——	General average of 46 estimates.	Average of 7 estimates reporting cost below 5 cents.	Average of 32 estimates reporting cost between 5 & 9 cents.	Average of 6 estimates reporting cost over 9 cents.
Yield in lint cotton per acre in lb. ..	180	290	209	100
	Dollars.	per	Acre	
Cost of lint in fields. Cents per lb. ..	5·60	3·54	4·77	12·86
Ginning and hauling per lb. ..	1·10	·84	1·07	1·44
Picking per lb. ..	2·21	1·69	2·14	2·27
Gross cost of lint per lb...	8·91	6·07	7·98	17·17
Less value of seed per pound of lint ..	1·18	1·82	1·16	1·13
Net cost of lint per lb. ..	7·73	4·25	6·82	16·04
Cost of lint in annas ..	3 as. 8½ p.	2 as. 0½ p.	3 as. 3 p.	7 as. 8 p.

We think that with this elimination of the extreme figures on both sides, leaving the average of the 32 replies showing cost of production 6·82 cents (3·273 annas) per lb., the result is a very fair representation based on the producers' own figures of the average cost of producing cotton in Texas, though as will be seen by the table, this cost depends principally on the yield per acre. No one can figure on the cost of a crop failure, and nothing is allowed for personal expenses of the producer and his family. Obviously, the man who raises a few bales of cotton and nothing else, will have a hard time getting along, no matter how high cotton may sell. It is, of course, understood that nothing is included in these figures for 'fertilizers.' In the Eastern belt this is a serious addition to the cost, though it is probably compensated for, to some extent, by increased yield per acre. Messrs. Norden also call attention to the publication in the 'Cotton Trade Journal' (Savannah) for April, of a statement of cost of production said to be made up of figures sent in by Mr. J. M. Barwick, one of the leading farmers of the Slarendin Country, South Carolina. Adding Rent and Wear and Tear to conform with Messrs. Norden's Texas calculations, Mr. Barwick's crop figures come out as follows :—

	$		RS. A.
Ploughing, putting in fertilizers, etc. 20 acres @ $8 (=Rs. 24) ...	160·00	or	480-0
Fertilizers 20 acres @ $25 (=Rs.75)	500·00	,,	1,500-0
Hoeing ...	30·00	,,	90-0
Rent ...	80·00	,,	240-0
Wear and Tear ...	15·00	,,	45-0
Picking, 35 bales @ 7·50 (=Rs. 22-8) ...	262·50	,,	787-8
Hauling, ginning, etc. 35 bales @ $2 ...	70·00	,,	210-0
Gross cost of production ...	1117·50	,,	3,352-8
Less seed ...	262·50	,,	787-8
Net cost of production of 35 bales of 500 lb. each=17500 lb. ...	855·00	,,	2,565-0
Cost of 1 lb. ...	4·89 cents	=	2·347 annas.

In the light of these figures it is difficult to accept the Southern assurances that the farmers "will go to the poor house on 8 cents (3 annas and 10 pies) cotton" and that they "must have 10 cents (4 annas 9½ pies) to live above want," unless indeed we interpret 'want' in the liberal sense of the economists.

The first thing that strikes us in India is the cost of fertilizers placed at Rs. 75 per acre : then comes the rent, Rs. 12, and ploughing and putting in fertilizers Rs. 24. The cost of producing 875 lb. of seed cotton per acre or roughly 300 lbs. of lint was Rs. 167-10 less Rs. 39-6 for seed, amounting to a net cost of Rs. 128-4 and on this a very good profit was made.

The sums expended will appear fabulous to the Indian peasant, and are far beyond his present means, but fairly well-to-do landlords will probably endeavour to succeed with manures, and in course of time the ordinary farmer will follow, even if he has to borrow the money: and he will do so the more readily if village banks come to his aid.

From the analysis of the plant and its produce it will be easy to ascertain the quantities of the chief manures removed from the soil by a crop. An average crop takes 54 lbs. Nitrogen, 19 lbs. Phosphoric acid and 40 lbs. Potash. If Nitrate of Potash be used for the Nitrogen, it is at once taken up by the crop, and not much is required; but as the danger is great of its being washed away by the rains, it may be advisable to use the ordinary oilcakes of the country, well ground. According to Souteiran and Gerardin, til seed contains 5·57 per cent. Nitrogen, and 10 cwt. of this should be sufficient to supply the Nitrogen required per acre. If 1½ cwt. of Bonemeal or Basic Slag were scattered evenly over the field before the first ploughing, there would be a sufficiency of phosphoric acid, and a cartload of ashes, or 3 cwts. of Kainit, or 1 cwt. of Muriate or Sulphate of Potash, used with the Bonemeal or Basic Slag, would be enough for the necessary Potash.

From experiments made on the peasants' own fields at Barsi, in the Deccan, it is evident that fertilizing pays, and pays well.

Worked in the ordinary way, without any interference whatever with the Kunbi's agricultural methods, various plots were manured with different fertilizers, with the result that, though all were otherwise treated alike, the crop was very different.

From the unfertilized plot the return was 50 lbs. lint; with 4 tons of cattle manure a similar plot returned 80 lbs. lint, whilst those treated with roughly ground earth nut and til seed cake together with bone and potash produced 150 to 200 lbs. of lint. The difference in crop could be seen at a glance, and the weighments, taken as the crops matured only confirmed the expectations raised from a glance at the fields. Although Rs. 25 was paid for oil seed cake, Rs. 5 for bonemeal, and Rs. 8 for potash, in the absence of ashes, per acre, the cost of fertilizers was about half the average found in the American reports given in the preceding pages. The other items of expenditure stand no comparison with those to which an Indian household is accustomed, and there is no doubt that a large increase of wealth is open to India if only a proper system of manuring the cotton fields is resorted to.

Taking the lint crop roughly at one-third of the lint and seed crop combined, the following are the results of the Barsi trials :—

1.	Unmanured ...	50 lb.
2.	Manured with 4 tons cattle dung ...	80 „
3.	Nitrate of Soda 1 cwt. and superphosphate 1 cwt. ...	120 „
4.	The above and Kainit 1 cwt. ...	150 „
5.	Nitrate of Soda 1. cwt. and 2 cwt. each Super and Kainit ...	180 „
6.	Groundnut cake 2 cwt. and 2 cwt. each Super and Kainit ...	200 „

The land had received very little attention for years, and the chief point kept in view was to spend as little money as possible in fertilizing, so that in no case was there a sufficiency of nitrogen. Where Nitrate of Soda was used much must have been lost during the heavy showers that followed after the top dressing, and thus, contrary to expectation, the groundnut cake showed better results than the Nitrate of Soda, which can be explained by the fact that a great part of the latter was washed away. The fields treated with artificial fertilizers gave crops far in excess of the cotton-fields in the districts around.

According to reports from the Department of Agriculture of the United States, one acre of land producing 300 lb. lint is deprived of the following quantities of the chief plant-foods :—

	lb.	Nitrogen.	Phosphoric acid.	Potash.
Lint ...	300	0·72	0·18	2·22
Seeds ...	654	20·25	6·66	7·63
Pods ...	404	4·54	1·14	12·20
Leaves ...	575	13·97	2·57	6·57
Stalks ...	658	5·21	1·22	7·74
Roots ...	250	1·63	0·38	2·75
Total ...		46·32	12·15	39·11

The lint takes practically nothing from the soil, and cotton and cotton-fields might be fruitful indefinitely if only the seeds could be returned in the shape of well-ground cake, since the oil contains nothing of importance to the growth of the plant which cannot be supplied in large quantities by the soil.

In America practical experience points to the benefit derived from heavy phosphatic manuring, though the chemical analysis shows so little phosphoric acid taken from the soil. Though a crop of 300 lb. of lint removes from 13 to 20 lbs. phosphoric acid off the land it is coustomary in the United States to add to the Nitrogenous and Potassic fertilizers no less than 600 lb. of superphosphate, containing about 80 lb. of phosphoric acid. The greater part of the phosphoric acid found in the crop settles in the seed, as we see from the analyses of the Commissioner of Agriculture, Washington, U. S. A., in his report of 1874. According to these, the ash of the cotton seed contains per cent.—

Potash	... 35·44	Soda	... 0·81
Magnesia	... 15·06	Lime	... 4·45
Phosphoric acid	... 30·01	Sulphuric acid	... 3·22
Oxide of Iron	... 1·07	Chlorine	... 0·49
Carbonic acid	... 3·46	Sand & charcoal	... 5·96

From this we see that potash is contained in large quantities in the seed, and the fact that Magnesia is present in as large a quantity as 15 per cent. points to the particular form of potash to be used, viz., Kainit, which contains sulphate and chloride of magnesia to the extent of 27 per cent. together with 12·55 to 14 per cent. of potash.

It is evident that half the food-stuff taken up by the plant finds its way to the seed, and though the lint is what is chiefly required in commerce, it is merely a protection designed by nature for the seeds to enable them to be more widespread and self-sown, where the plant is found in its wild state.

As is the case wherever manures have been tried, a complete manure always proves best in growing cotton, and a well-balanced fertilizer will be the cheapest.

From experiments undertaken by J. D. Wood, of Hardeman County, Tennessee, on loam with a stiff clay sub-soil, we find the following results :—

		Crop. (Lint and Seed).
1.	Unmanured ...	218 lb.
2.	Superphosphate 300 lb. & Chili Saltpetre 45 lb.,	695 ,,
3.	Superphosphate 300 lb. in April; Kainit 242 lb. ,, ,,; Chili saltpetre 45 lb. ,, May	775 ,,

The unmanured plot gave a return equal to about the average of a good year in the Bombay Presidency.

The difference between an unmanured plot and one treated with a complete fertilizer is plainly shown in the figures given by W. E. Hodges, Arkansas.

The unmanured acre produced 100 lb. lint and seed per acre, while that manured with :—

470 lb. cotton seed cake
600 ,, superphosphate
480 ,, Kainit
2000 ,, lime, produced 1000 lb. do. do.

In Drs. Felber and Walta's "Die Kaliduengung in den Tropen and Subtropen," we have an account of experiments with Egyptian cotton, that show only too plainly the value of manures, and that the greatest crop is obtained from a complete fertilizer :—

		Lint and seed per acre
1.	Unmanured ...	786 lb.
2.	70 lb. Chili saltpetre	965 ,,
3.	Guano 58 lb. ...	1,032 ,,
4.	Guano 121 lb. ...	1,236 ,,
5.	Chili saltpetre 51 lb. and Muriate of Potash 85 lb.	1,137 ,,

	Lint and seed per acre.
Chili saltpetre 36 lb.	
6. Muriate of Potash 90 lb.	1,338 lb.
Superphosphate 90 lb.	

Here evidently the soil had a sufficiency of nitrogen, for in no case was there enough of this plant-food in the shape of fertilizers to produce an ordinary, and far too little for a bumper crop. But previous green manuring had supplied this.

In India, on the other hand, an insufficiency in the soil is the rule, and consequently, when quick-acting nitrogenous manures are too costly or not available, it is advisable to raise quick-growing leguminous crops, and to plough them into the soil about flowering time.

But far more interesting than experiments carried out in foreign lands are those we find in India itself in the growth of indigenous cotton.

Owing to the courtesy of the present Director of Agriculture, Baroda State, Mr. M. A. Sitole, B.A., Bar.-at-Law, M.R.A.C., we are enabled to supply a set of experiments. The net results compare not unfavourably with those of the United States of America; and it is to be hoped that a continuation of such experiments may lead to still better results. If a complete manure be taken as a basis in all trials, and duplicate plots be used to correct any variation in the soil when final comparisons are made, a change in the quantity of the plant-foods in turn, only one being changed in each plot, will soon lead to a decision as to the most paying and cheapest manure.

It is a pity similar experiments have not been tried in various parts of the country. If every year such trials were made on a fairly large scale in the centres of cotton districts, much good would be attained. A comparison should be made between the expenditure in raising cotton in the States and that in India. The net profit by the use of manures will be found to tell in favour of India, and especially in the districts where Broach cotton is grown, immense gains will result.

When we leave generalizing and come to actual figures we are overwhelmed with the gain that would accrue to the country by the use of well-balanced concentrated fertilizers. Were such manuring general (and the ingredients can all be procured in this country), what would be the net profit the Baroda figures show us? But leaving these aside, if we suppose an average extra profit of Rs. 5 per acre, the sum goes into crores of rupees for the whole country.

Such an aim is worth endeavouring to attain, and the means are within the resources of the farmers.

Appended is the "Statement showing the results of the Manurial Experiments with Cotton of the Baroda Model Farm for 1909-1910."

There is a remark against plot 20A which is not quite clear. It reads:—"But there should be some Farmyard manure at least 10,000 lb. costing Rs. 10." The general remarks on all the experiments is also not quite plainly expressed, viz., "The Bajri crop which was in rotation with the above cotton yielded 102 maunds 32 lbs. only. The result of the above experiment cannot be taken as conclusive and true, as this was the first year of the experiment and the plotting made was very defective."

However the results are given for what they are worth.

It is to be hoped others may be induced to undertake similar experiments on similar lines, and benefit themselves and the raiyats of the country.

CROP—BROACH COTTON.

Plot	Manurial Treatment.	Quantity.	Cost.			Cultivation Charges.			Total cost of cultivation per acre.			Out-turn per acre.				Profit or loss per acre due to manure.		
			Rs.	A.	P.	Rs.	A.	P.	Rs.	A.	P.	lbs.	Rs.	A.	P.	Rs.	A.	P.
16	Superphosphatee .. Potas. Sulphate ..	300 lbs. 100 ,,	20	5	4	46	1	3	66	6	7	708	106	3	3	39	12	8
16a	Potas. Sulphate ..	100 ,,	8	5	4	46	1	3	54	6	7	944	141	9	7	87	3	0
17	Superphosphate ..	300 ,,	12	0	0	46	1	3	58	1	3	1,182	177	4	9	119	3	6
17a	Ammonium Sulphate Potas. Sulphate ..	100 ,, 100 ,,	18	5	4	46	1	3	64	6	7	838	125	11	3	61	4	8
18	Ammonium Sulphate .. Superphosphate ..	100 ,, 300 ,,	22	0	0	46	1	3	68	1	3	1,228	184	3	3	116	2	0
18a	Farmyard .. Ammonium Sulphate .. Potassium ,, .. Superphosphate .	10,000 ,, 50 ,, 50 , 150 ,,	25	2	8	46	1	3	71	3	11	1,020	154	3	5	82	15	4
19	Farmyard ..	20,000 ,,	20	0	0	46	1	3	66	1	3	1,136	170	6	5	104	5	2
19a	Ammonium Sulphate .. Potassium .. Superphospate ..	100 ,, 100 ,, 300 ,,	30	3	4	46	1	3	76	6	7	1,356	203	6	5	126	15	10
20	Farmyard of equal value of Ammonium Sulphate	20,000 ,,	20	0	0	46	1	3	66	1	3	1,000	150	0	0	83	14	9
20a	No top-dressing ..	..	..	..	..	..	..	..	46	1	3	995	149	6	5	93	5	2
21	Ammonium Sulphate ..	100 ,,	10	0	0	46	1	3	56	1	3	984	147	9	7	91	8	4
21a	Sodium Nitrate ..	150 ,,	15	0	0	46	1	3	61	1	3	1,140	171	0	0	101	14	9
22	Tank silt ..	20,000 ,,	20	0	0	46	1	3	66	1	3	984	134	1	7	68	1	3
22a	Poudrette ..	20,000 ,,	30	0	0	46	1	3	76	1	3	1,058	158	11	3	82	10	0
23	Farmyard every second year before cotton ..	20,000 ,,	20	0	0	46	1	3	66	1	3	1,398	209	11	3	143	10	0
23a	Nil	..	..	..	..	46	1	3	46	1	3	534	80	1	7	34	0	4

Plot 23A with no manure returned by no means a small harvest of 534 lbs. and a net profit of Rs. 34. Judging from the remark column of the report and from the out-turn, plot 20A was manured with 10,000 lbs. of farmyard manure, which increased the harvest over the unmanured plot by 462 lbs. per acre, and the net profit by Rs. 49. This shows only too clearly the benefit to be derived from the use of manures well within the means of the raiyat. Doubling the amount of the farmyard manure, by an expenditure of Rs. 20, the net profit rises to Rs. 104, in plot 19, and the extra expenditure of Rs. 10, causes a further gain of Rs. 20, or a net extra gain per acre of Rs. 10. Plot 23A confirms these results; for, though 20,000 lbs. farmyard manure was to be employed every second year only, this was the first year and the whole quantity had been used. The net profit was Rs. 143, or Rs. 109 above the unmanured plot, and Rs 60 above that manured with only 10,000 lbs. but the difference between plots 20 and 23, viz., 1,000 and 1,398 lbs. of seed cotton, or Rs. 59 per acre is not easily explicable.

We find that the 'no manure plot' 23A is 16th or last in the list of out-turn and of profit, whilst plot 23, fertilized with 20,000 lbs. of farmyard manure, headed the list with an out-turn of 1,398 lbs. seed cotton and a net profit of Rs. 143 per acre.

Poudrette to the amount of 20,000 lbs. must be difficult for the ordinary cotton grower to obtain. It comes seventh in the out-turn list (1,058 lbs.) and twelfth under net profit, and may be omitted as not practical at present. 20,000 lbs. of tank silt is nearly as costly as artificial fertilizers, and cannot be got by many. Its out-turn ranks 11th, with Ammonium Sulphate, and takes

13th place in the list of net profit, though Rs. 68 is a net profit per acre well worth obtaining.

A study of the substitutes for farmyard manure in the shape of artificial fertilizers is open to us in this report. The results are sometimes puzzling, as when we find 150 lbs. of Nitrate of Soda giving an out-turn of 1,140 lbs. of seed cotton and the harvest taking 5th place in quantity and profit, (Rs. 109), while 100 lbs. of Sulphate of Ammonia returned only 984 lbs. or 10th place in produce and 7th place in profit (Rs. 93). Here one might be led to infer that the soil was wanting in potash, and that the soda in the nitrate took the place to a certain extent, of the missing potash ; but plot 16A treated with 100 lbs. of Sulphate of Potash, returned only 944 lbs. 13th in quantity and 9th in net profit (Rs. 87).

With incomplete manures we constantly get figures that puzzle, and, in a land like India, where such fertilizers are little understood, we do not see what advantage is to be gained at present by their use on demonstration farms, except, of course, when manuring leguminosae, when nitrogenous fertilizers might be unnecessary, if not harmful. Sulphate of Potash (Plot 16A), for instance, returns 944 lbs. whilst 3 cwt. of superphosphate added (plot 16) lowers the return to 708 lbs. the nearest approach to the unmanured plot. Yet superphosphate added to Ammonium Sulphate (plot 18) increased the harvest from 984 lbs. (plot 21) to 1,228, and the net profit from Rs. 91 to Rs. 116.

The effects of 500 lbs. of a complete fertilizer (plot 19A) viz., 100 lbs. Ammonium Sulphate, 100 lbs. Potassium Sulphate, and 300 lbs. Superphosphate, costing Rs. 30, and taking the place of 20,000 lbs. of farmyard manure valued at Rs. 20, are seen in the harvest of 1,356 lbs. of seed cotton, i. e. only 42 lbs. less than plot 23 and Rs. 17 less in profit. It came second in the list for out-turn and for net profit. But half the quantity of fertilizer of plot 19A added to 10,000 lbs. of farmyard manure returned only 1,020 lbs. of seed cotton, and though the net profit was very good, viz. Rs. 82, it is down 11th in profit and 8th in out-turn.

Having placed these notes before the Director of Agriculture, Baroda State, he sent the following letter in further explanation of the remarks that accompanied his experiments :—

SIR,

I have the honour to acknowledge with thanks the receipt of your manuscript and the seed of tree cotton, sent with yours dated 20th instant.

With regard to your remarks in the manuscript on the cotton experiments, I wish to say a few words :—

(1) The remarks against plots No. 20A viz., " but there should be some farmyard manure, at least 10,000 lbs. costing Rs 10," can be explained thus :—

In plot No. 20A no farmyard manure was given at all. Had it been given and then if no top-dressing whatsoever was to be applied to this plot, we should have been able to compare its results with the adjoining plot No 18A which was also treated with 10,000 lbs. of farmyard manure, but which was given a top-dressing. Thus we would have been able to arrive at some results, regarding the application and non-application of top-dressing composed of a complete artificial manure to the cotton crop.

(2) There is a general remark that we are not in a position to demonstrate the rotation of Bajri with cotton from one year's experiment only, as many experimental errors are liable to creep in, though the utmost care is taken to avoid them; and in order to remedy this evil we must convince ourselves thoroughly by repeating the same experiment for two or three years more; and when we have done this, then and then only should we try to demonstrate this experiment to the cultivators, otherwise not.

(3) Plot No. 20 has been manured with 20,000 lbs. of farmyard manure in the same year, while plot No. 23 was manured with the same quantity and quality of farmyard manure, but in the year before the cotton crop was taken. Now plot No. 23 shows an increase of 388 lbs. of seed cotton over plot No. 20.

This shows that the cotton crop is more benefited by a previous manuring of the farmyard manure, than a direct application of it in the same year. This fact has been confirmed by the Bombay Agricultural Department and hence requires no other proofs.

The manuscript is returned to you per book post, with thanks.

I have, etc.,

(Sd.) M. SITOLE,

Director of Agriculture, Baroda State.

It will be interesting to watch the results of a continuation of these experiments for a few years, while new plots are laid out for dealing with complete fertilizers only, to ascertain the cheapest and most paying method of raising the best crop without permitting the soil to deteriorate.

But before making attempts with concentrated fertilizers the ordinary cultivator should be induced to fertilize his cotton fields with an annual application of a few tons of cattle manure. Even 5 tons thus used year after year are bound to show their good effects before long.

From the most interesting series of manure experiments, to be found in the Annual Reports of the Surat Government Experimental Farm, we can gather what can be done by the use of fertilizers within the reach of raiyats, and the gain to be obtained. Slight at first, the improvement continues as years go on, and the gradual increase is an object lesson that may be taken advantage of by the Indian farmer.

On similar plots, for three years in succession with no other rotation but jowar and cotton the unmanured plots returned an average of 191 lbs. of seed cotton, whilst the plots manured with 5 tons of farmyard manure resulted in a harvest of 300 lbs. per acre, and far better crops were obtained by the same manuring with the ordinary rotation found in various parts of the country, such as leguminous crops grown with or after jowar, which had succeeded cotton. It is true little farm yard manure can be spared for dry crops that pay as little as cotton does in many parts of the country, and cotton is very much neglected in this respect, but there is no reason why small trials should not be made to see how beneficial they may prove. Even if in the first year or two results are not so striking as one might anticipate, there is no doubt, that, in course of time, both the soil and the crops will be benefited to a great extent and the progressive farmer will see a plentiful return for using his brains when fertilizing his fields. He can use oil-cakes, bonemeal, saltpetre and ashes annually in small quantities where cattle manure cannot be spared for dry crops or is difficult to obtain. The raiyat is not asked to spend the very large sums employed for the purpose in the United States of America, but to use small sums year by year to keep his fields in fair condition.

To further illustrate the difference between crops obtained from unmanured fields and those manured in the ordinary way, we extract two experiments from the Bombay Crop Experiment Report of 1890—91. They were conducted at Jambusar and at Ankleshwar in the Broach District.

At Jambusar the local estimate of the harvest was 14 annas. The seed sown was 6 2/13 lbs. and the crop was 590 lbs. seed cotton, valued at Rs. 51-0-3. It was grown on a light brown soil locally called marugorat, growing bajri and cotton. It was not irrigated, but was manured before sowing in June, at 12 cartloads per acre. Cultivation was indifferent and the season a little below average, rain slightly deficient and the crop slightly affected by cold in February.

At Ankleshwar, on similar soil, where land was unmanured but had been left fallow for three years, there was a crop of 362 lbs. of seed cotton, valued at Rs. 28-5-4. The cultivation was good and the season as in the above experiment, but the out-turn was low.

Though 500 lbs. of seed cotton is a full average yield in Broach, that of the Bombay Presidency is about 184 lbs., showing how little is returned over large tracts of the country by the unmanured impoverished soil.

The area under cotton in India and the harvests are given below:—

In 1904-5.	14,918,000 acres yielding	3,826,000 bales or	102 lbs. per acre.
In 1905-6.	21,072,000 ,, ,,	3,426,000 ,,	65 ,, ,,
In 1906-7.	22,344,000 ,, ,,	4,908,000 ,,	84 ,, ,,

The bales weigh 400 lbs. each.

In the United States of Amercia there were:—

In 1888-9. 19,362,073 acres under cotton.
In 1904-5. 31,730,371 acres yielding 13,500,000 bales of 499 lbs. each or 212 lbs. per acre.

Yet a great deal more will be supplied by America; for, with careful selection of stock, and a good supply of manures, from 500 to 800 lbs. of lint have been obtained. In other words, India, with 70 per cent. of the American average under cotton yields only 26 per cent. of lint; and, if matters go on as at present in both countries, the Indian crop will be insignificant in a few years.

It will not be out of place here to reproduce from the "Times of India" three or four paragraphs, published on 30th June, 1910, which require the careful attention of all Indian cotton growers:—

"*The Opportunity of Cotton.*—For every reason then it is clearly the duty of the Indian Government to exert itself to the utmost to advance agriculture. It happens, fortunately, just now, that a very favourable opportunity offers for the advancement of Agriculture which makes it incumbent upon the Government of India to lose no time and omit no exertion to turn this favourable opportunity to the best account. India is a large producer of cotton and has been from time out of mind. Since the latter half of the 18th century however, the United States has become a much greater producer of the material. Indeed, the inventions that took place in the second half of the 18th century, and which resulted in increasing beyond all expectation the growth of raw cotton in the Southern States of the Great Republic, not only enabled these States to out-distance India in the growing of cotton, but practically gave rise to the cotton industry in England, and ultimately to the cotton industry all over Europe. Ever since the latter part of the 18th century the United States had kept the lead. But there are signs now that the cotton consumption in the United States is about to exceed the possible production of the United States. In a word the demand for cotton goods is growing in the United States with the growth of the population and wealth, and to meet that demand cotton manufacturing is extending throughout the Union and is being fostered by a prohibitive tariff. At the same time the cotton manufacture is growing also in all the other forward countries of the world. The result is that already the supply of the raw material, while adequate in years of good season becomes short in years of bad season, and at the present moment is so deficient that it has thrown the cotton manufacture out of gear everywhere.

More about America.—To illustrate what we have been saying about the production of raw cotton, we may state that the statistics published under the authority of the Liverpool Cotton Association, September the 15th 1903, show that the total crop of the United States in 1865-66 amounted to 2,314,476 bales. In 1887, 22 years later, the crops amounted to as much as 7,017,707 bales. The year was exceptionally productive, but making allowance for that, the figures strikingly show what exertions were made to stimulate the production of raw cotton during the two decades which followed the great Civil War, a period during which the South was almost entirely dependent upon the article for the recovery of its prosperity, and naturally, therefore, was straining every nerve to repair by its means the devastation brought upon it by the long and desperate struggle with the North. In 1908-09, 21 years later, the production had risen to 13,925,000 bales. It will be seen that in the first 22 years here recorded the increase in the cotton crops of the United States was 203·2 per cent., whereas the increase in the following 21 years was about 97 per cent. Here we have clear proof that since 1887-88 the rate of increase in production of raw cotton has been steadily slackening. Perhaps, it will interest the reader if we add that in 1866, the population of the United States was 34,469,000 ; in 1888, it was 59,974,000, and in 1909, it amounted to about 88,000,000, the increase in the first 22 years being 69·2 per cent., and in the subsequent 21 years 46·8 per cent.

And something about Egypt.—Egypt has become an important grower of cotton in the interval. Moreover, Egyptian cotton is of a very fine quality ; so much so, indeed, that Lancashire uses practically only American and Egyptian cotton. Efforts are being made to stimulate the growth of the plant in the Soudan, a country which appears to be admirably suited for its production. There are other countries which grow and still others which are capable of growing cotton, but at present these do not count for much. Except the United States and Egypt, the only great cotton grower is India. Indian cotton, however, at the present time, fs not suitable for Lancashire. The extension of cotton cultivation in Egypt has been very rapid and has added immensely to the wealth of the country—has, indeed, contributed in a powerful way to that improvement in the condition of the people which has been witnessed since the British occupation of the Valley of the Nile. Recently, however, there has been a great set back. Our readers are aware that the last cotton crop was a failure.

A problem of the Nile.— Until it began to be gathered in, it was thought to be one of the finest crops ever grown, and as there have been two exceptionally high Niles in succession, the belief was held almost universally. But when the gathering in was completed it was found that the crop had been hopelessly damaged. There is no doubt, of course, that much damage was done by worms, but there is a belief that the two high Niles, while so beneficial to Egypt in other respects, has not proved to be entirely beneficial to the cotton crop. There is, further, a belief that the growers of cotton have exhausted the fertility of the soil, not applying manures as was desirable. The Egyptian Government at present is taking every means within its power to set matters right; we hope with success. But, however that may be, the existing state of things shows that just now a favourable opportunity offers, which if turned to good account, may enable India to get a better position in the cotton trade than she holds at present.''

But progress is not to be made just now by experiments with exotics, or an interference with the raiyat's mode of tillage and rotation till he is able to supply the necessary manures. Above all, for a time at least, all attempts to cultivate in one district a variety that pays better in another district, must be avoided, and trials with exotics must be restricted to experimental plots for many years.

WHEAT.

After rice, the largest area cropped in India is wheat, and under this cereal there are more than 23 million acres.

If the addition of one bushel (60 lbs.) to the cereal harvests of India would pay all the taxes, it is a great pity and an incalculable loss to the country that the peasants have not yet learnt to imitate other lands in the means employed to increase the out-turn of their wheat fields.

In the "Agricultural Gazette," New South Wales, Australia, for September 1903, there is an interesting tabulated statement showing the average yield of the harvests in the chief countries of the world.

The average for the years 1892—1901 is as follows :—

		Bushels.
Great Britain	...	32·91
Holland	...	28·86
Denmark	...	28·18
Belgium	...	27·94
New Zealand	..	27·44
Germany	...	25·57
Sweden	...	24·00
France	...	18·51
Canada (Ontario and Manitoba)	...	18·24
Japan	...	17·54
Austria	...	15·53
Servia	...	14·59
Bulgaria	...	14·00
United States of America	...	13·29
Italy	...	12·90

		Bushels.
Roumania	...	12·36
Argentina	...	11·34
Spain	...	10·80
India (including Native States)	...	10·46
Poland	...	9·79
North Caucasia	...	9·76
European Russia exclusive of Poland	...	7·95
Australia	...	7·06

Although Australia as a whole shows so low an average, that of the County of Willoughby is 18·3 bushels per acre.

It is worth noting that Belgium in 1902 led the way with 34 bushels, followed by Great Britain with 31·22 and Germany a near approach with 30·33, whilst Canada followed with 25·60, and Austria and France and Roumania showed 20 bushels each.

As usual those countries have the biggest and best crops that resort most to manuring, and, where concentrated fertilizers are brought on the farm to be added to the ordinary dung, the result is a harvest far in excess of the average.

German agriculturists are not satisfied with merely learning what in theory is best for their fields; they experiment to ascertain what will give the best crop, and then apply the result of their experiments to their farms.

In Krichauf's "Manuring with Potash" we find the proportionate quantities of plant-foods taken from an acre of land by an ordinary crop of wheat, as follows:—

		Wheat.	Straw.	Total.
Nitrogen	...	69·9	25·1	95·0
Phosphoric Acid	...	26·5	11·9	38·4
Potash	...	17·4	32·5	49·9

A bumper crop would take more.

As the manures and fertilizers applied may not place all their nutrient properties at the disposition of the first crop, it is advisable to use greater quantities than the analyses appear to justify, and, in the case of phosphoric acid, to supply proportionately larger quantities, as experience teaches us that it results in bigger harvests.

If we look around the world for the largest harvests in wheat, we find that the Duchy of Anhalt can boast 33 bushels per acre. Now it must be borne in mind that there are large potash mines in this province, and, potash being cheap on the spot, is much resorted to as a fertilizer.

Professors Wagner and Maercker, as well as other authorities, have stated that, with potassic manures, the average yield of grain is 1,470 lbs. more (if 200 lbs. potash be used) than from land not so manured. Whether the soil be good, bad, or indifferent, the use of this fertilizer always increases the harvest returns. Belgian soils, which average the best wheat returns, are rich in potash, but, whilst a good crop removes 64 lbs. of potash from the acre, the dung used as a manure returns only 44 lbs., so that, in course of time, the soil must become considerably poorer unless potash is used in fairly large quantities as a fertilizer.

Some of the reports we have from that country will not easily be credited by the Indian peasant. M. Jaques of Hillecourt made the following experiments :—

		Harvest per acre.
1.	Without manure	24·38 bushels.
2.	Nitrate of soda 80 lbs. Basic Slag, 480 lbs.	37·32 „

3. Nitrate of Soda 80 lbs. Basic Slag 480 lbs. Muriate of potash 160 lbs.	Harvest per acre, 49·36 bushels.

What a gold mine the Punjab would become if anything like these results could be obtained. Yet there is no earthly reason why similar crops should not be grown by means of well-balanced fertilizers.

Of course the same formula might not be suitable. Probably a great deal more nitrogen might be required, and nitrogen is the principal constituent of the plant-food of cereals. But in the Punjab itself there lies at the door of the farmers the nitrogen and potash, in saltpetre, that would supply two of the three plant-food ingredients, and bone or basic slag would complete the fertilizer. Since cereals are apparently thankful for magnesium and calcium salts, and even for a little common salt, kainit, which contains all these as well as potash, can be recommended as the means of conveying the potash to the plants. As some people may be afraid of the soil caking by its use, it may be mentioned that Dr. Schneidewind recommends kainit as the best potassic manure for cereals, and, so long as not more than 3 cwt. is applied per acre, no damage need be feared to the texture of the land. Muriate of potash, which contains four times as much potash and about one-third the amount of common salt, will also be found an excellent potassic fertilizer.

Professor H. Boiret recommends the use of phosphoric acid to give the straw of cereals more rigidity to cause earlier ripening, and to produce heavier grain.

Australian farmers depend to a very great extent on phosphatic manures alone; but this must result in a constant loss of nitrogen and potash, so that after some years the harvest will dwindle till it is not worth the labour of growing wheat. But the influence of phosphoric acid on heavy bearing has no doubt been abundantly proved, and, provided the law of minima is borne in mind, we may agree with Mr. John Woolley of Skimblentt Farm, Montgomeryshire, who produced the big wheat crop of 77 bushels, when he says "a good phosphatic heart is the foundation of all profitable agriculture."

In a small pamphlet like this it would be too costly to insert illustrations taken from photographs in the field, but as a sample of what may be done by Indian farmers at no great cost to test the value of concentrated fertilizers, the following report is placed before them of small experiments in East Prussia :—

Manure per acre.	Harvest per acre.		Value of Harvest.	Cost of Fertilizer.	Profit above unmanured.
	Grain. lbs.	Straw. lbs.	Rs.	Rs.	Rs.
1. Cattle dung ..	1,150	2 650	91	..	..
2. Cattle dung with 450 lbs. Superphosphate and 150 lbs. Nitrate of Soda .	1,950	3,250	146-4	25-14	30
3. Cattle dung with 450 lbs. Superphosphate, 150 lbs. Nitrate of Soda and 200 lbs. 40% Potash Salt ..	2,400	4,250	182-14	31-14	60

Here we see not only the benefits to be derived from the use of fertilizers, but the fact stands out clearly that a complete manure, even if somewhat more costly in the initial expenditure involved, repays the farmer wonderfully.

As, however, the raiyat may not care to risk even the expenditure on one acre, we would suggest trials on a very small scale at first, such as we find in Professor P. Wagner's interesting Fourth Leaflet on Manurial Questions. The experiment with wheat was made on sandy loam, rich in nitrogen, at a place called Ernsthofen. Notwithstanding the fact that the principal plant-food ingredient was by no means wanting in the soil, a nitrogenous manure is used in the trial, for it ought to be the aim of every farmer to keep his land, like his animals, in good condition, while getting from it the greatest possible profit.

The experimental plots were one-fiftieth of an acre each, and the price of the fertilizers well within the means of the Indian raiyat.

Without manure the harvest was—

	Grain 31 lbs.	Straw 73 lbs.
A complete manure produced	,, 48 ,,	,, 127 ,,
Or a gain per acre of	,, 850 ,,	,, 2,700 ,,

The fertilizer was made up of four lbs. 38% potash salts, 2 lbs. double superphosphate, and 4 lbs. nitrate of soda.

If experiments are first tried on a small scale like this, it will be an encouragement to increase the size of the experimental plots and finally to try larger experiments in the field.

There is an old saying, common in England, pretty well appreciated throughout Europe, but not yet well understood in India, viz.: "you will get nothing for nothing, and d——— d little for a half-penny." The sooner this is understood by the native wheat grower the better for him.

When the value of incomplete fertilizers is known, much benefit may be derived from their use ; the return from an unmanured plot, for instance, being 1,520 lbs; whilst a similar adjoining plot treated with 800 lbs. of basic slag produced 2,560 lbs. on the farm of M. Billiard at Montiers, and an acre, giving a crop of 496 lbs. at Badonvilliers, returned to Messrs. Mussier and Massal 1,472 lbs. by the use of 800 lbs. of the same fertilizer. For a long time to come, however, complete manures will be necessary in India, and, where cattle manure cannot be had in sufficient quantities, concentrated fertilizers, such as saltpetre and basic slag or bone and the various oilcakes available in the country together with ashes will produce as good crops as these, if not better. It is a question of judicious manuring, and all the more necessary in India, where the soils are not often rich in nitrogen.

To show again the difference between incomplete and complete manures the following table of the average crops of experiments in triplicate, conducted by Mr. J. Keller of Ernsthofen will be useful:—

	Grain, cwts.	Straw, cwts.	Profit above the unmanured plot.
1. No manure ..	29·2	12·1	£ ..
2. Manured without potash .	43·5	13·8	£ 0-13-6
3. Manured without phosphoric acid ..	43·1	16·2	£ 1-13-6
4. Manured without nitrogen ..	42 4	19·6	£ 1-16-8
5. Complete manure ..	50·80	19·2	£ 3- 7-0

But it is not only the amount of grain that is to be considered in the harvest. The quality of the straw, whether for feeding or for other purposes should also be borne in mind. Sir Henry Gilbert investigated the statement, frequently made, that the strength of wheat, barley and wheat straw is dependent on a high percentage of silica in their composition. He found, on the contrary, that a high proportion of silica in the straw meant a low proportion of organic substance, and hence brittleness and not strength of straw was the result. The strength of straw depends upon the favourable development of the woody substance of the cellulose, and as this has the characteristics of the carbohydrates, it is always beneficial to use potash, which has been found to be exceedingly useful in their formation. Experiments at Rothamsted confirmed this. On two plots growing barley, Phosphate and Ammonia salts were applied on the one, and on the other Potash was added to the above salts. The straw on the non-potash plot grew worse as the experiment continued, so that in unfavourable seasons it was brittle enough to be crushed into fragments in the hand, while on the potash-manured plot the straw remained stout and healthy. The chemical analysis further confirmed this, for 13·2 lbs. per acre of potash was found in the straw of the first plot, and 39·5 lbs. in that on the second; so that, besides the increase in the grain, there is a great improvement in the straw when a complete manure, containing a sufficiency of potash, is used. Even where farm-yard manure is employed in fairly large quantities, such as 12 tons, on soils that in Europe are said to be in fair condition, other concentrated fertilizers can be usefully added; but, in India, where it is seldom possible to use 5 tons per acre on wheat soils, by no means rich in plant-foods, a judicious expenditure on artificial fertilizers will amply repay the farmer.

In the advertisements of agents for fertilizers we often find such examples given :—

"Result obtained in 1903, on Heavy Loam in poor condition, by Mr. John Woodyatt, the Hill Rock, Bewdley, Worcestershire.

Manure applied per acre	Yield per acre.	
5 cwt. Kainit 1 cwt. Nitrate of soda	11 cwts. 26 ,,	32 lbs. corn. 32 lbs. straw.
The above plus 6 cwt. Basic Slag	20 ,, 50 ,,	104 lbs. corn. 104 lbs. straw.

Of course the increase and consequent profit is put down to Basic Slag. Any other phosphatic manure decomposing as quickly would have given equally good results, not on account of the phosphatic manure merely, but because it supplied the necessary amount of that special substance required to make the manure complete, so that the plant could have all the ingredients placed at its disposal to form its requisite nourishment.

As usual we have laid stress on the increase of the quantity of the harvest, leaving the question of quality alone for the present, first because the manures and fertilizers if well balanced and complete are sure to effect a certain improvement in quality also, and secondly because the increase in quantity must first be demonstrated before the raiyat will attend to further improvements. We cannot expect altruism from the Indian peasant any more than we can look for it from the European farmer. Show the raiyat a reasonable profit and he will follow advice soon enough. He cannot be expected to spend money and take risks in experiments for the benefit of others. Year in, year out, we have preached this simple text, and we are pleased to find in the Annual Report of the Department of Agriculture for the year 1908-1909, that the Government at last sees the necessity to work on these lines. As usual, of course, the idea of increasing the yield is restricted to selection. What selection will do without the most careful attention to manuring is not difficult to foresee. But, having failed in attempts to improve other crops by the introduction of pardeshi and exotic varieties, it is a puzzle to us why the same eternal plan must be continued in this case to add to the record of failures in the Department. When will the Government first try to increase the returns by the chief means adopted in Europe before going the round of all the old failures? There may be too much concentrated science even in a scientific Department under the British Government in India, and we are not surprised to learn that farmers would be more pleased to hear of bumper crops on Demonstration Farms, by the use of fertilizers within the means of well-to-do raiyats, than to learn of repeated hopeless failures in the pursuit of some wonderfully scientific aim.

Notwithstanding the numberless trials in all parts of the world showing the necessity for complete well-balanced fertilizers, we have the old experiments begun in India as if no one in the world had even tried them before, viz., green manuring, fallow, incomplete fertilizers, and finally one complete if ill-balanced fertilizer, based evidently on some guess, which shows at least the benefits to be derived from a manure containing all the principal plant-foods. Whether this will be of any use in the succeeding trials, Heaven only knows. Most likely the same old list will be continued and the same number of pages filled in when the Annual Report is sent on, till, in course of years, we have volumes enough to make up an Encylopædia of useless knowledge.

However, it is somthing to have even these trials made, away at Mirpurkhas Agricultural Station. for, though scarce a page of the returns is worth much, it shows only too clearly the benefits to be derived from a combination of Nitrogen, Phosphoric Acid and Potash in the plant-foods for wheat.

The following is extracted from the last Report (1908-1909) :—

TREATMENT.	Yield per acre Grain in lbs.	No. of waterings.
1. Sunn ploughed in ...	640	2
2. Mung and Mutki ...	860	2
3. Fallow ...	480	1
4. Nitrate of Soda 1 cwt. top-dressed Bone-dust 3 cwt. every third year ...	547	1
5. Sulphate of Ammonia=1 cwt. Nitrate of Soda Bone-dust 3 cwt. every third year ...	878	1
6. Sulphate of Ammonia=1 cwt. of Nitrate of Soda. Sulphate of Potash ½ cwt. Bone-dust every third year 3 cwt. ...	1152	1

Let us now see the difference appearing in India between manured and unmanured wheat fields, and compare the profit obtained by the Indian farmer with what can be shown by farmers in Europe.

In the "Crop Experiments," Bombay Presidency, 1888-89, we have a carefully compiled report by Mr. H. Woodward, Assistant Collector, Ahmednagar. The field was in Nervasa (Kharvandi) and is described as unirrigated best black soil, manured in April by folding sheep and goats three days. Rotation 1. wheat, 2. jowari (late) and 3. bajri. Cultivation fair, and season favourable. 1,000 lbs. is considered a full crop. A little

Kardai was sown with the soft red soda wheat and the resulting harvest was 856 lbs. wheat and 18 lbs. Kardai.

Calculating expenditure as if incurred in the payment of labourers, (the family did all the work), the cost of raising the crop on 10 acres 39 gunthas was, in round. numbers Rs. 150, thus:—

	Rs.	A.	P.
1. Man and three pairs of bullocks for 30 days ...	33	12	0
2. Folding sheep and goats for three days, their grazing and food for attendants...	1	8	0
3. Harrowing. 2 pairs of bullocks and 1 man, 10 days. 1 pair and 1 man, 5 days ...	10	10	0
4. Sowing. 2 coulter drill, 3 men and 2 pairs of bullocks for 4 days ...	4	12	0
5. Watching. 1 man, for 2 months at Rs. 4 ..	8	0	0
6. Reaping and binding. 6 men for 15 days..	16	14	0
7. Carrying to grainyard. 2 pairs of bullocks, 3 men for 4 days ...	4	12	0
8. Threshing. 4 men and 4 pairs of bullocks, 8 days ...	16	0	0
9. Winnowing. 2 men and 2 women for 4 days ...	2	8	0
10. Carriage to market ...	3	0	0
11. Cost of seed. 2 maunds of wheat at Rs. 4 and 4 seers Kardai at 1¼ annas ...	8	5	0
12. Wear and tear of implements and bullocks. 3 pairs of bullocks at Rs. 40 per pair lasting 7 years Rs. 17, implements repaired and replaced Rs. 2 ...	19	0	0
13. Village haks (dues) ...	9	0	0
14. Assessment and Local cess ...	11	13	5
Total ...	149	14	5

The yield per acre =	Rs.	27	3	7
The cost " " =	"	13	10	6
and the net profit	Rs.	13	9	1

In this case the manuring cost Rs. 1-8-0 and yet the harvest was a fairly satisfactory one, for it brought a profit that, in India, is considered good.

With this let us compare the figures of receipts and expenditure of a wheat harvest from an acre in England.

Cost of producing a Wheat Crop.

	£	s.	d.
Dunging at 16 loads per acre ...	0	8	6
Ploughing—2 horses at 1 acre per day ..	0	5	6
Extra allowed for skim coulter.	0	1	0
3 horse rolling 7 ft. 6 ins. wide	0	0	8·6
8 strokes of the harrow before drilling @ 4½*d*. ...	0	2	9
Drilling with 2 horse drill 7 ft. 6 ins. wide ...	0	0	6·6
1 stroke of harrow after drill ...	0	0	4·1
Total tillage ...	0	19	4·3
Spring rolling with 3 horses ...	0	0	8·6
Harrowing ...	0	0	4·1
Harvesting ...	0	9	6
Threshing ...	0	4	10
Dressing (winnowing twice) @ 2 *d*. ...	0	1	4
Marketing ...	0	2	6
	1	18	1

Cost of producing a Wheat Crop.

	£	s.	d.
Labour charges ...	1	18	1
Seed 3 bushels @ 5s. (good quality) ...	0	15	0
Dressing or Pickling ...	0	0	6
Rent, Rates, Taxes ...	1	5	0
Incidental expenses ...	0	2	5
Total cost per acre ..	4	1	0
Average Crop 4 quarters @ 32s.=	6	8	0
Straw ...	1	10	0
	7	18	0
Deduct ...	4	1	0
Book profit per acre ...	3	17	0=Rs. 57 12 0

Summary of expenses and profit on the following 4 years' rotation :—

	Expenses.			Value of crop.			Profit.		
	£	s.	d.	£	s.	d.	£	s.	d.
Wheat ...	4	1	0	7	18	0	3	17	0
Roots ...	5	0	0	6	0	0	1	0	0
Barley ...	3	5	8	7	10	0	4	4	4
Clover ...	2	7	1	4	0	0	1	12	11
	14	13	9	25	8	0	10	14	3=Rs. 160 11 0

It would be difficult to supply anything like 16 loads of dung to the acre of wheat in India, but Dr. J. W. Leather in the Agricultural Ledger "Indian Manures," 1897, says :—"The general conclusion which we may draw from these experiments, (the increase in the harvests due to cattle manure) is that, with an application of 6 tons per acre of cattle manure, there will be obtained an increase of some 300 to 400 lbs. of wheat per acre in the N. W. Provinces, or Bengal, and at Nagpur from 200 to 300 lbs."

In the same Ledger he attempts to show that, properly conserved, there would be enough manure to supply the dry crops with 6 tons per acre; but, unfortunately, this most important manure, the mainstay of the agriculturist, is much neglected in India. To prove how it will pay the raiyat to manure with the means at his disposal, viz., the excreta from cattle and men, we have a series of experiments carried on for 11 years, which can be summed up as follows, the average being given of the standard and duplicate plots :—

——	1884-88.	1888-92.	1892-95.
No manure, grain...	983 lbs.	1181 lbs.	1086 lbs.
Cowdung 180 maunds ,, ...	1363 ,,	1579 ,,	1579 ,,
Poudrette, ,, ...	1424 ,,	1610 ,,	1775 ,,

In the Agricultural Ledger No. 10 of 1893, we have a note from the pen of Mr. T. Basu, Assistant to the Department of Land Records and Agriculture, on "The Dumraon Farms :—" What they teach." From this we extract a few words which may be useful not only to the raiyat but also to those who say artificial fertilizers are unknown to the Indian farmers, and are not likely to prove beneficial in this country. "The Behar raiyat," says Mr. Basu," knows the value of nitrous earth for the poppy crop; in other parts of India it is used also for tobacco, wheat, chillies, and other valuable crops. What is wanted is only an extension of the existing practice."

This has been done, to a certain extent, but not quite on the right lines. When only an incomplete manure is used the results are not satisfactory for any length of time. Below are given, in tabulated form, the results of a series of experiments commenced in 1885-86 and continued till 1899-90 is given.

MANURE.	YIELD.																			
	1885-86.				1886-87.				1887-88.				1888-89.				1889-90.			
	Grain.		Straw.		Grain.		Straw.		Grain.		Straw.		Grain.		Straw.		Grain.		Straw.	
	Mds.	srs.	Mds.	srs.	Mds.	srs.	Mds.	srs.	Mds.	srs.	Mds.	srs.	Mds.	srs.	Mds.	srs.	Mds.	srs.	Mds.	srs.
1. No manure ..	14	5	17	12	6	12	6	32	9	17	13	25	10	32	16	5	11	4	15	2
2. Saltpetre 3. Mds. per acre ..	27	10	62	31	18	18	24	8	18	5	21	31	17	12	35	25	15	32	25	3
Increase under Saltpetre	13	5	45	19	12	6	17	16	8	28	8	6	6	20	19	20	4	28	10	1
	Rs.	A.	P.		Rs.	A.	P.		Rs.	A.	P.		Rs.	A.	P.		Rs.	A.	P.	
Value of increase ..	37	10	0		33	5	6		24	6	5		27	0	0		13	4	0	
Cost of saltpetre .	9	6	0		9	6	0		9	6	0		9	6	0		9	6	0	
Net increase in profit due to saltpetre ..	28	4	0		23	15	6		15	10	5		17	10	0		3	14	0	

Here we see clearly that the use of a deshi fertilizer within the means of the ordinary raiyat repays itself handsomely; but we also see the dangers arising from the continued use of incomplete manures.

Saltpetre, when pure, contains large amounts of nitrogen and potash, but no phosphoric acid. Now every harvest takes a fair quantity of this plant-food off the field, till the store available for the plants is nearly exhausted. Then the crops must suffer. We have learnt from the law of minima, that, though a soil may be ever so rich in one plant-food such as nitrogen, or in another such as potash, or in both, the crop will not be good unless we have a sufficiency of phosphoric acid. In the experiments tabulated above, we find the plants supplied with a yearly allowance of nitrogen and potash, with the result that the soil must give up its stores of phosphoric acid to produce the crops, and, as the results show, in course of time the harvest must fall, till, after some years, owing to the want of phosphoric acid, the whole must end in complete failure.

It is painful to find the Department looking for extraordinary reasons in the decrease of the harvest, when the cause was patent. Here is what we find in the Report:—"On considering the results, it will appear that the increase in the outturn, resulting from the application of saltpetre, became gradually less every year, so that in the last year of the experiment a net profit of Rs. 3-14-0 only, on account of this manure, was left, against Rs. 28-4-0 in the first year. This fact would teach us not to expect that, because saltpetre is a good manure for wheat, it ought to bring a large outturn when applied year after year to the same land. Saltpetre acts best for the first two or three years, and on soil which has been exhausted by continuous cropping without manure for many years. When land can be manured with ashes, it will be found profitable to use nitre in addition to them."

Is it not strange that the first principles of agriculture are ignored in attempts at explaining the gradual decrease in the harvests. One would think the law of minima had never been heard of by the Department. As if to strengthen the extraordinary deductions drawn from the experiments, Dr. J. W. Leather, Agricultural Chemist to the Government of India, is cited as informing the Editor of the Dictionary of Economic Products that "At Cawnpore saltpetre both by itself and in conjunction with ashes of cowdung, has proved a very valuable manure for wheat and maize. Moreover, this confirms the results obtained in England, viz., that a nitrogenous manure is the most valuable for the cereal crop."

It may be the most valuable, as it is the most costly, and generally the most needed, especially in Indian soils; but it must be remembered that, without a sufficiency of phosphoric acid and potash in the soil, no bumper crop will be obtained, notwithstanding the application of tons of the costliest nitrogenous fertilizers. Absolutely necessary as the component part of a complete plant-food, more phosphoric acid is needed in the fruit, in this case the wheat grain, and it is in this harvest we find a regular fall year after year as the store in the soil is consumed and nothing is added to the field to replace it. The straw harvest is more irregular; for its chief supplies consist of nitrogen, potash and silica and very little phosphoric acid is requisite to make the food for straw complete.

Where some farmyard manure can be used it is always advisable to employ it, not merely as a fertilizer, but also for the beneficial effect it has upon the physical conformation of the soil. If, to about 5 tons of this, 2 cwt. of bonemeal or basic slag, and 1 cwt. of kainit could be added, the resulting harvest would be excellent. The further addition of 1 or 2 cwt. of nitrate of potash (saltpetre) would probably produce a bumper crop. In Australia where they know their soils are rich in nitrogen and potash, as in Flowerdale, 4 cwt. of bone-dust used for potatoes, serve to produce 20 bushels in the succeeding wheat crop, and at Longford the use of 1½ cwt. bone-dust got from Sidney, returned 23 bushels of wheat ; but, where the use of artificial fertilizers is new, we cannot recommend such as contain one, or at most two of the principal plant-foods, but should be inclined to insist on manures containing nitrogen, phosphoric acid, and potash.

In 1894-95 a complete manure was used and the difference is striking. The harvests were :—

	Plot.	Manure.		Per plot.		Per acre.	
				Grain.	Straw.	Grain.	Straw.
1.	800 sq. yards.	None	lbs.	392	687	2371	4156
2.	,,	Bonemeal. 480 lbs. Saltpetre 240 lbs.	,,	533	903	3224	5463

The Nagpur Farm reports both the value of complete manures and the difficulty of obtaining results that might otherwise be expected when the area is not irrigated and fertilizers like bonemeal cannot decompose in time to place at the disposal of the plants the plant-food or foods they may contain. Taking the unirrigated portion first, we find that, though there is a profit from incomplete manures, it diminishes as years go by, and that, even where complete manures are used, the decrease is fairly constant; for a very small portion of a fertilizer such as bonemeal will decompose when the amount of water the soil receives is slight, but that even though the bonemeal appeared a waste at first, its effects are seen even on unirrigated land.

			Unirrigated.			
			Average 1885—89.		1890—94.	
			Grain.	Straw.	Grain.	Straw
1.	Unmanured	lbs.	799	1287	418	796
2.	Bone-dust 360 lbs. per acre	,,	891	1388	534	882
3.	Saltpetre 240 lbs.	,,	1133	1711	751	1468
4.	Saltpetre 240 lbs. per acre Bonemeal 360 lbs. per acre	,,	1094	1751	865	1538

The difference between the manured and unmanured portions on irrigated land is pronounced, and shows only too clearly the advantage to be obtained from a complete fertilizer:—

Average for the years 1890—94:—

			Unirrigated.		Irrigated.	
			Grain.	Straw.	Grain.	Straw.
1.	Unmanured	lbs.	418	796	486	820
2.	Bone-dust 360 lbs. per acre	,,	534	882	626	954
3.	Saltpetre 240 lbs.	,,	751	1468	931	1789
4.	Saltpetre 240 lbs. Bonemeal 360 lbs.	,,	865	1538	1012	1924

A proper rotation may often supply the nitrogen wanting in the soil; but care must be taken that other manures are added, or the harvest may show astonishing changes and end in losses.

We have an interesting series of experiments carried on from 1884 to 1895, on two plots, both unmanured, but on the one the wheat invariably followed indigo, which had been removed before the wheat was sown. The results are :—

	1884	1885	1886	1887	1888	1889
Unmanured ...	1514	623	1367	847	786	653
Following indigo ...	1590	1107	1791	1283	1379	835

	1890	1891	1892	1894	1895
Unmanured ...	1464	1162	690	877	287
Following indigo ...	1988	1136	1258	696	287

In both cases we have a final decrease in the harvests till they approach disappearing point; but the plot on which wheat followed indigo gave better results for several years.

A similar series appears in the Agricultural Ledger of 1895, No. 11. Here we have saltpetre used as a fertilizer and it contains nitrogen and potash, but no phosphoric acid. As seen before, the results are very uneven, and though at first they appear excellent, in course of time the law of minima is enforced by nature. On the Nagpur Farm the experiment was carried on from 1885 to 1893, with the following results :—

			1883	1886	1887	1888	1889
1.	No manure	lbs.	1055	763	1060	760	525
2.	Saltpetre 240		1555	990	1610	1470	610

		1890	1891	1892	1893
1. No manure	lbs.	887	515	540	230
2. Saltpetre 240		987	1227	612	420

We cannot but notice the gradual decrease in the returns year by year as the land becomes impoverished. The great increase on the manured plots continues while a sufficiency of available mineral matter is in the soil ; but the decomposition of the land placing these at the disposition of the plant being irregular, owing to climatic differences in different years, the results on this plot are very uneven, and the decreasing store sends the harvests downwards, till, in course of time, the want of phosphoric acid is so decided that the land cannot return paying crops.

From the reports of the Nagpur Farm we see that the average wheat harvest from 1883 to 1887 was :—

Unmanured	...	1039	lbs.	grain.
Complete manure	...	1514	,,	,,
Increase over unmanured	...	475	,,	,,

Cattle duing is a complete manure, and we have seen how its regular use results in an undiminished increase over the unmanured plots. It seems so unnecessary to repeat this. The raiyat knows it, but has not enough manure or the money wherewith to purchase it. But, in these days, when co-operative societies are spreading over the land, and the money they lend ought to be spent on that most important thing in farming, the manuring of the soil, it may not be out of place to show the large results obtainable by the use of a few tons of a manure that is never very costly when it can be got.

On the Cawnpore Farm the following were the results of manuring with 132 cwt. of cattle dung as compared with unmanured plots :—

			1884	1885	1886	1887	1888
1.	No manure	lbs.	1031	635	913	1041	968
2.	Cattle dung	,,	1428	900	1537	1258	1246
			1889	1890	1891	1892	1893
1.	No manure	lbs.	883	1307	1222	992	1500
2.	Cattle dung	,,	980	1585	1537	1331	2474

No doubt the effect of good tillage is seen in the fair returns obtainable so long on the unmanured plot, but even good tillage would not be sufficient in course of time. The effects of the 132 cwt. of cattle dung per acre are so evident and the results so progressive that no comment is required.

Similar results are apparent on the Dumraon Farm, only in this, the fall in the returns in the unmanured plot is very apparent.

		1886	1887	1888	1889	1890	1891
No manure	lbs.	1154	516	672	884	910	606
Cowdung	,,	1514	610	908	1154	1386	866

On the Cawnpore farm we have a most interesting experiment with green manures ploughed in. Sunn gathers its nitrogen from the air, and, in decomposing, returns to the soil the mineral matter taken from it. There is a very peculiar occasional fall in the returns every now and again, an explanation of which would be worth learning. The unmanured plots, as usual, show the deterioration that goes on rapidly when crops are removed from the soil annually and no manure is added. The results are:—

	1882	1883	1884	1885	1886	1887
No manure lbs.	777	1198	1182	659	709	751
Green Sunn ploughed in.—lbs.	1978	1737	1733	1404	660	1500

	1888	1889	1890	1891	1892
No manure lbs.	587	447	484	635	345
Green Sunn ploughed in lbs.	1285	814	1122	1113	1125

The soil must have been originally fairly rich in phosphoric acid and potash, though poor in nitrogen. The Sunn did not increase the mineral matter, but, as the crop was ploughed in, it was not lost. The nitrogen was increased with every crop of Sunn. Had phosphoric acid and potash been added when the Sunn was ploughed in, bumper crops would have been obtained annually.

Of course, the expenditure on farms in Europe is much heavier per acre on account of the cost of manure, the price of labour, etc. The returns, however, are so much greater that the net profit in Europe is very much higher than we find it in India. And this is absolutely necessary to keep the farmer in the comfort he enjoys, which to the Indian peasant, would be the lordly way of life of the Saheb.

But, if manure is not used, i. e., if little expenditure is incurred in raising the crop, a small harvest will result. Occasionally in India the land is allowed to lie fallow for years, and a crop of 1,129 lbs. of grain with 1,433 lbs. of straw can be obtained from black soil. In the crop Experiments for 1890-91 we find such to be the case, but on similar soil in the same season, the lack of manure on regularly cropped fields results in an outtrun of 669 lbs. grain and 645 lbs. straw.

Besides the small crops obtained when manure is not used, there is a further danger of the harvest being considerably lessened by an attack of Rust.

It will be noticed that parasites attack sickly plants most, as white ants eat into decaying or dead wood. In order to prevent such attacks (and prevention is better than cure) plants should be kept in good heart by an application of sufficient manure. They will then not be so easily attacked and be able to resist disease to a very great extent. It has been noticed that early sown wheat seems to escape the attack of Rust. Seasons for sowing must however be maintained if good harvests are to result; but, if we cannot sow earlier, we are able to bring the crops to maturity quicker. This can be done by the use of easily soluble phosphatic manures, such as superphosphates and basic slag, which give strength to the plants, increase the grain harvest, and ripen it earlier. An addition of these to the ordinary farmyard manure will be found of great benefit.

When we compare the average outturn in India with that of Great Britain, we can understand the difference in the wealth of the people. Why should not the 627 lbs. average per acre of wheat obtained in India be made the 1,974 lbs. average of England, and why should 3,000 lb. crops on garden lands be infrequent? We have so many Co-operative Societies starting all over India. It is to be hoped their first endeavour will be to urge their members to purchase manures, so that their harvests may increase, and the foundation be laid of the future prosperity of the country.

At Rothamsted wheat has been growing on the same land for 70 years.

The results obtained are :—

1. On the calcareous clay loams of Rothamsted the unmanured plot of wheat continues to produce 10 to 15 bushels of wheat per acre, a constant yield.

2. 14 tons of farmyard manure averaged 33 bushels.

3. The continuous application of nitrates and ammonia salts raises the yield considerably above the unmanured plots, but exhibits palpable signs of exhaustion. Average yield in 32 years 20½ bushels above the unmanured plots.

4. A mixture of nitrogenous and mixed mineral manures, compounded to represent a complete dressing, calculated to restore and add to the stock of plant-food in the soil, maintained a yield of 32 to 36 bushels per acre for 32 years.

5. When only mineral manures were used one year and ammonia and nitric acid and salts the next on the same plot, the year mineral manures were used alone they were only slightly better than the unmanured plots ; but when the ammonia or nitrate was used the harvest that year rushed up to the level of the completely manured plots, showing (*a*) that the minerals were retained in the soil beyond the year in which they were put in, (*b*) and that the ammonia and nitric acid salts were not retained longer than a year.

6. When dung is applied continuously to land, the accumulation of unexhausted fertility becomes very large, and the removal by crops of the substances accumulated would extend over a long series of years.

The area under wheat, in India according to the Agricultural Statistics of 1904-05, was over 23 million acres. We have seen the large net profit made by the use of complete well-balanced fertilizers: allowing an increase of only Rs. 5 per acre, we get the enormous extra net profit of Rs. 115 millions. This is certainly no trifle, and is worth the attention of the leaders of public opinion in India. True patriots ought to give their attention to the Banks that will improve Agriculture. With a change in the peasants' lot, Swadeshi enterprises must start up as a natural consequence, and education must of necessity accompany them, so that, the Indian politician, who looks a little ahead, instead of considering Agriculture as a question to be attended to at some distant date, when a greater political freedom will have been attained, will do his best to introduce true scientific farming, confident that, with the increase of wealth and education, he can speak of the wants of the country, backed by the great majority, the millions engaged in Agriculture.

Since the above was written the October issue of the Agricultural Journal of India made its appearance. In its Notes under the heading "Concerning Soil Fertility" reference is made to Circular No. 142 published by Dr. Cyril C. Hopkins, of the Agricultural Station of the University of Illinois.

On the subject of fertilizers, natural and artificial much has appeared in the series of pamphlets on "Indian Crops treated from the Manurial Point of View" and the frequent reference to these caused even so friendly a critic as the *Hindu* to give us a quiet dig in the ribs. Quoting from the "Revival of Agriculture in India" the Editor says:—"In some places improved irrigation was the cry raised, and oil-engines and pumps were considered the royal road to fortune; in others, iron ploughs were the instruments to which would-be reformers nail their faith, etc.," and then with the smile of the unbeliever he adds:—"Others again pin their faith to chemical manures and artificial fertilizers as the salvation of the Indian raiyat." Even Dr. Mann, in the pages of the Pusa Journal, writes:—"With some of the details of Mr. Kenny's suggestions, we are not in agreement. We do not believe, for instance, that one of the *great* needs of the Indian cultivators is a supply of artificial manures. We have little evidence, again, of the progressive deterioration of most of the land in India which Mr. Kenny considers as certain."

In reply, we can merely say, what is admitted by all, that India has not a sufficient supply of natural manures, that the land has been longer cultivated than Europe and America, and that, if in those countries, manuring is considered the principal cause of the great increase of crops, the use of artificials in conjunction with cattle manure, or alone where farmyard manure cannot be obtained, is *a fortiori* more necessary. The question of price is quite another thing, and does not render the manuring less necessary. It is to be hoped the formation of Agricultural Banks will enable the raiyats to purchase artificials at a rate that will render their use highly remunerative. In introducing the circular referred to, the Editor of the Agricultural Journal asks a very pertinent question:—"Will it also pay in India?" The answer emphatically is:—Fertilizers in conjunction with farmyard manure or used alone where farmyard manure cannot be had, will pay, provided complete well-balanced fertilizers are employed, and even the Bombay Department of Agriculture, that has blundered along with ill-balanced incomplete fertilizers for so many years, is now beginning to see the value of complete manures.

As to the little evidence of progressive deterioration of Indian soils, we have only to refer to wheat lands which return 4 bushels per acre, and ask if something similar is not the case with other crops in India.

Since the publication of the report of wheat growing continuously at Rothamsted, many have jumped to the conclusion that land deteriorates only to a certain point, after which a fixed return may be expected annually, *ad infinitum* without having recourse to manures.

We must remember that, though 70 years may be quite long enough to prove soil deterioration, it is an infinitesimally short period to prove complete exhaustion, and that the history of England and its agriculture is but the story of yesterday compared with the long period during which India has been under tillage.

If well-tilled though unmanured lands on one of the most scientifically developed experimental farms in the world show the lowest point of deterioration on wheat plots as represented by a crop of 10 bushels, we have reached this point as the present average of Indian wheat fields, and, consequently, the returns from this country must show a very large number of acres returning practically nothing. This will tend to show the deterioration point reached by us, and may serve to check conclusions arrived at by a perusal of Rothamsted reports.

Any way, we know that manures improve the crops; we, know also that, where cattle manure cannot be obtained in sufficient quantities, artificials take their place and give splendid returns; and if we wish to benefit the Indian raiyat, we should first show him the way to increase his crop, as is done everywhere else in the world. This managed, he will be ready to sit at anyone's feet to learn scientific farming, or anything else that will benefit him. But, in the name of common sense, show him a profit first, and do not expect to convert him by railings at and condemnation of everything he has hitherto considered good farming, and learnt by practical experience to appreciate.

SUGAR-CANE.

Already in the time of the Romans India was known for its sugar. Pliny tells us of a sweet salt obtainable from India and used in his time medicinally. It is evident that the cane was grown here from time immemorial and that refined crystallized sugar was made long ago in India. All over the country the natives grow the cane, and at present the attention of planters in Bengal has been called to the profits to be derived from the cultivation of this plant. Large tracts have been experimented on with great success, and all the forces of modern knowledge will be brought to the help of the sugar grower. It is time the natives brought science to their aid in the management of their sugar farms. Already the complaints are many and loud of sickness and failure in the crop, and, as years go by, the losses will be heavier. It is the old story. The soil has been overtaxed and refuses to give a return for the outlay.

By persistent effort and scientific methods the sugar beet has been wonderfully developed, so that five-eighths of the world's supply of sugar is derived from it. While this improvement of the beet industry has been in progress, the cane, in many countries, has received little or no attention. Prices of sugar have declined, but the cost of producing it in the old way has remained the same. The natural result was that, in many cases, the sugar planter did not realise the real conditions confronting him until he found his profits gone and his estates encumbered with debt. Fortunately some countries and some planters more wise have been modern, progressive, and abreast with the advanced thought of the age, and these are to-day leading the world in the production of sugar.

In India nitrogenous manures are used to a very fair extent, but phosphoric acid and potash are seldom employed: and even the nitrogenous fertilizers used contain such a quantity of salts that the end for which the cane is grown can scarcely be obtained, because one per cent. of common salt renders 12 per cent. of sugar deliquescent. The canes may look large, thick and juicy, but comparatively little sugar is obtained.

With combination and co-operation on the part of the sugar growers and a system of manuring based on scientific principles, India might supply the world with sugar. But if sugar cultivation is to spread the *Abkari* system must be changed. It is not a question at present, of small sugar factories or great central refineries. As long as the sale of liquor is confined to certain contractors, to whom the right is auctioned, the present need of small refineries along the banks of canals will not be met. A very heavy item in all sugar factories is the quantity of molasses to be dealt with. Whilst the sale of liquor is restricted to the one licensee, profit on the rum manufactured cannot be depended on. Government might possibly find it difficult to receive and dispose of this important by-product; but till it can be sold in an open market, at a fairly remunerative price, sugar-refining in India must languish, and hundreds of thousands of tons will annually find their way into Hindustan from Germany and Austria. Once, however, the Abkari question is settled in a way that will not prejudice the interests of the sugar-refiner, factories will dot the land, a very great impetus will be given to sugar-growing, and, instead of importing vast quantities of sugar, India will become the largest exporter of this product.

In this country the cultivation of sugarcane is limited not only by the poverty of the people and the supply of water for irrigation, but also, and to a very great extent, by the inability to procure a sufficiency of manure and ignorance of artificial fertilizers that should be added to cattle-dung to make the manure complete and well-balanced.

Owing to the ravages of white ants the stable manure must not only be well-rotted, but must remain exposed to the atmosphere and weathered during the rains; for the termite attacks not only the cane but consumes a good deal of the manure also. Of course the value of the manure must suffer considerably from such exposure and depreciate to a great extent, but this is better than having the canes eaten. Mr. E. C. Ozanne, writing of the Bombay Presidency, says the dung of cattle, mixed with house sweepings and other refuse, is the chief manure for cane, as indeed for all other crops. In Guzarat and Canara great care is taken of the muck-heap. Elsewhere apathy and ignorance prevail.

This may be said of the whole of India with rare exceptions.

From 150 to 200 maunds per acre and even as much as 400 maunds are used in various parts of the country.

In the neighbourhood of large towns poudrette is extensively used especially around Poona, Sholapore, and Ahmednuggar; but, according to Watt's Dictionary of

Economic Products, "this has become too popular and the cane cultivators would do well to use it rather as a supplementary fertilizer than as the sole manure."

In all such cases the nitrogen appears to be the only food looked to, and it is rarely we come across any attempt to supply phosphoric acid or potash. In some places as in Bassein, North Thana, where the climate is too moist and the cattle-dung is demanded for rice cultivation, castor-cake imported from Guzarat is the only manure. Castor-cake is also used in considerable quantities around Samalkot and along the East coast in the Madras Presidency. In some parts sheep and cattle are penned in the fields that are to be placed under cane, and in others the ashes of the crushed cane and similar materials used as fuel in making sugar are returned to the land. Mr. Wray, a West Indian planter, strongly condemned this, but I have never found the native of India wrong in the choice of his manures when he can obtain them, and a closer investigation will prove that it is the cheapest way of obtaining the potash the soils of those districts sadly need. In certain Provinces of Bengal unburned cowdung is never used, as it is believed to stimulate the growth of the canes, which thus become liable to fall down, and the natives there are convinced that, though it produces a larger quantity of cane-juice, the juice is, however, much less sweet in consequence. And this is quite in accord with the teachings of science. Large quantities of cattle manure will contain a certain amount of salt which improves the growth of the cane wonderfully but reduces the quantity of sugar contained in the juice. The Poona district growers should bear this in mind. Unfortunately for them the Government experiments have shown splendid growths of juicy canes by the use of enormous quantities of cowdung and poudrette, which was a waste of nitrogenous manure and certainly did not produce a corresponding quantity of sugar.

It so happens that scarcely anywhere in India is it settled what is meant by raw sugar. In the West Indies it is generally said that the yield of crystallizable sugar is two to three tons per acre now, in Java, 3·6, in Egypt 2·2, in Queensland 1·6. In India, the average given for coarse sugar is one ton per acre; but, if what is meant by coarse sugar, is gur, the actual yield of refined sugar in India would be little more than one-third of a ton. Reports on sugar one hundred years ago show refined sugar obtained per acre as 9 cwt., which would be about 27 cwt. of gur.

The yield of cane to the acre is 36 tons in Java, in Queensland 16, in India 15 to 20 tons.

But it is still difficult to arrive at definite figures as to sugar when reports are given concerning the outturn in gur, which is of different qualities containing varying amounts of molasses. There is little to wonder at in the poor returns of raw sugar when we consider that, to obtain the necessary amount of phosphoric acid and potash, the crop must be so heavily manured for nitrogen· The result is not only a great waste of nitrogen, the costliest ingredient of a manure, but an accumulation of salts which the sugarcane, greedy feeder that it is, takes up with the other plant-foods. It the Straits Settlements, Demerara and Louisiana, as well as in India, lands impregnated strongly with saline matter produce a cane which grows most luxuriantly but the juice is affected very prejudicially and consequently the sugar made from it. Many writers have pointed out that the presence of "*reh*" or other salts in the soil, beyond a certain proportion, invariably results in a watery juice, deficient in crystallizable matter. Mr. Wray mentions that, in Province Wellesley, he had "known sugar that was quite salt produced the first year from such land, and on this account sugar estates on the Sunderbunds had to be abandoned."

In all experiments, wherever made, it is found that on ordinary soils, the highest percentage of sugar is obtained from unmanured soils, but the quantiy of cane is of course small.

It should be the object of the sugar-grower to use such manure as will give the very highest return of cane and juice containing at the same time the highest percentage of crystallizable sugar.

For nitrogenous manures green manuring is resorted to in many parts of India. If, to obtain a plentiful supply of this, phosphoric acid and potash were applied to the green manure crop, there is little doubt it would prove an excellent fertilizer. Phosphatic manures are unknown to the peasant, and the trials made with them by Government officials in the Bombay Agricultural Department were so ridiculous that the scientific world would be too astonished even to smile were the experiments more widely known.

Four tons of bone used alone, or, still worse, 4 tons of superphosphate per acre, used for the nitrogenous contents, *mirabile dictu*, have been gravely reported on as inefficient. One would think so. As to potash, though it is used in the shape of ashes, wherever there is a fair supply obtainable, by the raiyat, we find scarcely a mention of it in the Government reports, notwithstanding the excellent results obtained from its use in various parts of the civilized world.

According to the report of the Department of Agriculture, Bombay Presidency, for the year 1894 "the weight of manure to be applied to each plot is to be regulated by the percentage of nitrogen it contains. Equivalent weights of nitrogen to be applied to each plot. The percentage of other elements of value will be known, and any marked difference between the plots will no doubt be traced to the value of elements other than nitrogen. Count will be taken of these differences, and deductions will be made which will eventually regulate the manner in which two or more manures may be mixed with the object of reducing cost and getting equally good results. Poudrette has been taken as a basis, and of this manure 42 tons per acre have been given—the quantity used in the district by the best cultivators of sugarcane."

Here we have a question of nitrogen alone being taken into calculation, with the pious hope that "the value of elements other than nitrogen will be traced," but how traced and to what, the soil or the manures or the crop, we are left to guess. The practice of the cultivators is taken as a basis or standard and there is little question of scientific experiments. The law of minima appears to be absolutely ignored, the value of potash as a carrier of nitrogen, unknown, and the benefits to be derived by the use of phosphoric acid in the formation of sugar unthought of. Muck, and plenty of it, or other manures containing as much nitrogen, keep the attention. That a reduction of expense could be effected and an improvement of the harvest by the use of less nitrogen and some phosphoric acid and potash does not appear to strike those concerned in these experiments.

Sufficient for them is the fact that cattle and farmyard manure in fairly large quantities are used by the best and wealthiest farmers around. It may also have struck the experimenters that the manure in question is complete—though that is doubtful; but whether it is well-balanced for the particular crop in question does not seem to have entered their minds. Considering that the manures were chosen for the amount of nitrogen they contain, we are not surprised to find them both incomplete and ill-balanced, when they are substituted for cattle-dung. Bonemeal would supply no potash, dissolved bones neither potash nor nitrogen worth mentioning. Yet such are used in experimental plots. "Farmyard manure and cattle-dung were applied before they were thoroughly decayed, with the result that, although according to analysis, they contained each "one per cent. of nitrogen probably more of it immediately available," (sic) the young cane was starved for a time." And from this a practical lesson is learned. We are inclined to ask:—"By whom?"

On page 14 we find a statement that sugar-cane refuse is of little value as a manure, and this is based on an experiment in which bones (whole, crushed, bone-meal, or dissolved bone is not stated), sugarcane refuse, ash, and urine were applied. The results are said to bear out a widespread belief held by cultivators that the refuse ash obtained during the process of gul-making is practically worthless as a manure. And this decision is reached merely from the germination of the crop, before the harvest can possibly be known or guessed at.

The worthlessness of the next year's experiments with 'comparative manures', is published in the words:—"The reputed percentage of nitrogen in the manures used differs greatly from actual percentage." We must bear in mind that the manures were rated according to their reputed nitrogenous contents alone. How great these differences are will surprise any one acquainted in any degree with ordinary analyses of concentrated fertilizers, and be scarcely credited by any one connected with model or experimental farms, or scientific farming.

Dissolved bones, i. e., superphosphate from bonemeal averages 0·5 per cent. nitrogen. The amount of nitrogen in 3,520 lb. superphosphate would be, according to this, 17·6 lb. of nitrogen; but page 32 shows no less than 130 lb., or seven times as much. Again 3,520 lb. dissolved bones and 1,290 lb. of saltpetre give, according to the statement on page 32, no less than 250 lb. of nitrogen. This presumes 130 lb. of nitrogen in the dissolved bones and leaves 120 lbs. for the saltpetre, or 9·3 per cent., a very crude saltpetre, containing no doubt large quantities of common salt, which, though it may help to make the canes large and juicy and fit for eating, must detract considerably from the power of the plant to form chrystallizable sugar.

As nitrogen is supposed to be the plant-food governing the results in these experiments, our attention is naturally attracted to the plot treated with dissolved bones. According to the report, the 6 tons of superphosphate contained 434 lb. of nitrogen. The usual analysis would show 67·2. The weight of canes was 80,325 lb. of tops 17,005, and of gul 9,870 lb. Evidently nitrogen was not the controlling factor in this harvest. The fish manure 5 tons was supposed to supply 600 lb. of nitrogen at the rate of 5·3 per cent. against a later analysis of 9·30. The nitrogen should therefore be nearer 1,052 lb. per acre. The harvest was 105,490 lb. of stripped canes, 14,335 tops, and 13,400 lb. of gul.

Here we have an expenditure of 67 lb. of nitrogen against 1,052 lb., and yet no note is made of the other chief ingredients of plant-food that must have aided the small amount of nitrogen in the dissolved bone and the larger supplies in the soil to result in a harvest of 9,870 lb. of gul.

In the plot manured with bones fermented with sugarcane ashes and urine, there is a remarkable result which passes quite unnoticed in the report. Potash is well known as a carrier of nitrogen. A great deal of it settles in the tops of the canes, which is not the case with phosphoric acid. The plot in question had stripped canes 47,950, tops 11,175, as compared with the fish-manured plots 195,490 lb. stripped canes, and 14,335, tops, i.e., with only 40 per cent. of a harvest in cane, it showed 70 per cent. in tops. In the notes not a word of reference appears about the potash and its patent effect; everything said is about nitrogen.

When from this single experiment without even a check plot, we get the decisive conclusion :—"The results are considered conclusive and this plot will be utilised to test the value of one of the edible oil cakes as a manure in the reserved scheme," we are not prejudiced in favour of any other deductions made from the results of these experiments.

The very experiments before us prove that nitrogen alone, though an important plant-food constituent in the manure required by the sugarcane, is certainly not, and cannot be the determining factor in the sugar harvest. The following are results taken from the report (except that the real and not the imaginary amount of nitrogen is placed after dissolved bones):—

	Nitrogen	Canes.	Gul.
Dissolved Bones	67 lb.	80,325 lb.	9,870 lb.
Castor Cake	462 „	95,830 „	12,235 „

	Nitrogen	Canes.	Gul.
Karanj Cake	441 ,,	80,600 ,,	10,640 ,,
Cattle Dung	43 tons	50,510 ,,	6,115 ,,

The dung was supposed to supply one per cent. nitrogen, or considerably more than is found in that of ordinary cake-fed cattle, and consequently amounted to over 960 lb. Yet, with the greatest amount of nitrogen, it produced a miserably poor harvest.

In another experiment with 3 tons of dissolved bones and 1 ton of saltpetre the harvest resulted in 105,735 lb. cane, 13,975 lb. tops, and 13,225 lb. gul, though the actual supply of nitrogen was only 291 lb.

It is admitted "Dr. Leather has proved that the amount of nitrogen is about five times as much as is taken up by a very heavy cane crop," but as if it were a satisfactory explanation of the great waste of nitrogen, we find the words added :—" It is less than that contained in a full dressing of poudrette or cattle-dung as given by the best cultivators in the district."

It does not appear to have struck any one connected with the farm that such enormous supplies of manure were required on account of the Law of Minima, and the phosporic acid and the potash requisite had to be supplied by the cattle manure even if the greater part of the costly nitrogen were to be wasted in the drainage water.

To take as a standard the amount of nitrogen found in the cattle manure used by the best and probably the wealthiest kunbis and to stick to this in spite of analyses of the harvest and of the manure does not show a scientific spirit. It is more than probable that a far smaller quantity would have been used by the Indian farmer could he have found ashes cheap enough for a potash supply. In the report of the Government Tests for the Incidence of Assessment we see that this has been done. At any rate, it is difficult to learn what object is aimed at when such enormous quantities of nitrogenous manure are placed on the fields. On good black soil in the Satara District in the Krishna valley, growing garden crops and sugarcane, tobacco and chillies, 15 cartloads of farmyard manure were added for the year, and the harvest of gul from Pandia was 11,312 lb. in 1890-91. Of course, manures had been used for previous crops, and the land was rich. But in the reports before us little note is taken of previous manuring in the calculation of results. No analysis of the soil is made to learn what quantities of nitrogen or any other constituent of plant-food was left from the previous fertilizing. Poudrette, containing 423 lb. of nitrogen for American sugar sorghum, is followed by 44·6 tons of poudrette containing 1,000 lb. of nitrogen for sugarcane. Considering the amount of nitrogen taken up by the crop, it is a woeful waste and extravagance. Again poudrette, containing 847 lb. nitrogen for cane, is followed by 3·3 tons of safflower cake containing 500 lb. of nitrogen. The plot manured with fish, containing 500 lb. of nitrogen had been previously manured with 600 lb. of nitrogen per acre. It is little wonder that we are inclined to respect what was said by Mr. Townshend many years ago, when, expressing his general disapproval of attempting to benefit the cultivation of the country by means of Government Farms, he added that "Government Farms were managed on a scale of expense that it was useless to expect that the raiyat would emulate."

To see how nothing practical has been gained on the farm by the use of incomplete fertilizers, we must merely add to the list of results that mentioned before as having been obtained from a raiyat's land in Satara, in 1890-91, and the comparison will need no comment.

Plot.				Gul	
1	Poudrette	44·6	tons.	10,737	lb.
2	Safflower	3·3	,,	12,320	,,
3	Mowra Cake	8·6	,,	7,725	,,
6	Cotton seed	7·1	,,	10,280	,,
7	Fish	2·9	,,	11,900	,,
8	Castor Cake	5·9	,,	9,820	,,
9	Karanj Cake	6·6	,,	9,770	,,
Satara	Farmyard	15	cartloads	11,312	,,

That the raiyats do not restrict themselves to cattle dung and farmyard manure is well known. In Khajurdi green manuring is also resorted to. At Bassein castor cake is used. The examples above are therefore not new to the Indian sugar-grower except as to the quantity used and the expense undergone.

Beginning with 500 lb. as the minimum quantity per acre necessary for a good crop of sugarcane, a modification is made in the year 1902, when 400 lb. becomes the standard. In 1905-6 this is still further reduced to 350 lb.; but to judge from the experiments upon which the decision is founded the figure might as well have been fixed by blind guessing.

Year after year we have the same trials with nitrogenous manures and no where do we find the analyses correct. The nitrogenous contents of the manures are supposed to be the same in all the plots, but *de facto* vary from 40 lb. to 210.

With the introduction of the Sewage Experiments at Manjri we have Dr. Leather's analyses "showing the weight of plant-food in the crop."

Description.	Weight. in lb.	Nitrogen. lb.	Phosph. acid.	Potash.
Clean cane	98,000	44·25	49·15	15·730
Green tops	14,840	29·83	15·88	91·71
Dry leaves	12,570	57·19	15·58	109·35
Total ...	125,710	131·25	80·61	216·790

Yet we find that for a crop of 101,331 lb. of sugar-cane which was estimated to require 124 lb. nitrogen, 77 lb. phosphoric acid, and 344 lb. potash, the plant-food estimated to be supplied by the effluent amounted to 735 lb. nitrogen, 353 lb. phosphoric acid and 274 lb. potash. In other words there was a deficiency of 70 lb. of potash, whilst the excess of phosphoric acid and of nitrogen amounted to 276 and 611 lb. per acre respectively.

These analyses, however, were productive of some good. Though, in the experiments carried out in the year 1903, there were two whose results should have struck the official in charge, they seem to have been passed over in silence. Plots 3 and 4 were treated with bonemeal and one with dissolved bone, respectively, as usual for the nitrogen they contained. 2,240 lb. per acre would allow 86 lb. of nitrogen from the bonemeal, and only 11 lb. from the dissolved bone. Yet the Gul harvest was 1,980 lb. from the plot getting 86 lb. nitrogen, and 3,575 lb. from the plot getting 11 lb. nitrogen.

But the next year introduces trials with manures other than nitrogenous. Again the idea of a complete manure seems unthought of. One plot manured with phosphoric acid and potash, but having no nitrogen yielded 8,788 lb. of gul of excellent quality. A comparison is made between this and another plot manured with 550 lb. nitrogen contained in farmyard manure and safflower cake. Yet this appears to have been done because phosphoric acid and potash, without nitrogen, were successful with Lucerne. Sugarcane is surely not a leguminous plant to be left without nitrogenous manure merely because this treatment suits Lucerne.

The minimum quantities of various plant-food ingredients essential for a good sugarcane soil have, with the exception of lime, not as yet been determined. Semlar, in his "Tropical Agriculture," Vol. III, page 224, states that the soil should contain at least one per cent. of lime. Nitrogen, phosphoric acid and potash should be applied artificially in almost every case, as the supply of these ingredients in the soil soon become insufficient for the needs of the crop. Sugarcane requires a considerable amount of the essential plant-food ingredients as shown by the detailed investigations of Mr. C. J. van Lookeren of Campagne Klatten in the "Archief voor de Java Suiker Industrie" 1893, page 397. This gentleman found that a crop of cane removed from the soil

	Nitrogen.	Potash.	Phos. acid.	Lime.
In 78,701 lbs. cane ready for crushing ...	40·9	85·0	40·1	16·1
In 54,305 lbs. tips and green leaves ...	10·5	33·5	5·0	4·9
In 9,523 lbs. dry leaves	23·9	52·6	7·8	50·6
Total ...	75·3	171·1	52·9	72·0

This table gives us a striking illustration of the use made by the plant of various fertilizers. The tips and green leaves and dry leaves require 34·4 lbs. of the nitrogen, whilst the cane takes 40·9 of the nitrogen, an equal quantity of potash is required for the leaves and cane, and more than three times the amount of the lime that goes to the cane remains in the leaves. The phosphoric acid, however, settles in the cane for the crystallization of the sugar, 40 lbs. serving for this purpose, against 12·8 lbs. for the leaves. It is not surprising then to find that in Luzon in the Phillipines, where the largest and best sugar producing canes are found, the soil is exceedingly rich in phosphoric acid.

By comparing the table given above with the requirements of rice we find how much more plant-food is taken from the soil and consequently how much heavier manuring it requires. It will be seen that the amount of phosphoric acid required by sugarcane is, relatively, unusually great, and the work done by the phosphoric acid, in increasing the return of sugar when compared with the weight of cane, is also very remarkable. Just as patent is the heavy drain of potash on the soil. Yet anyone who has visited sugar plantations in India must notice the comparatively heavy fertilization with nirogenous manure and the almost total absence of those containing phosphoric acid and potash.

In the " Tropical Agriculturist" of Ceylon for April 1902, a periodical of the greatest interest and importance to all engaged in agriculture, we find a quotation from the " Agricultural Journal " of February 1st, showing the plant-foods removed from the soil by seven different plants. It is decidedly instructive, telling us only too plainly what a terrible feeder the sugarcane is —

Plant.	Nitrogen.	Phos. acid.	Potosh.	Lime.
Sugarcane	127	44	298	71
Wheat	43	33	36	16
Barley	47	23	54	11

Plant.	Nitrogen.	Phos. acid.	Potash.	Lime.
Maize	61	31	66	14
Rice	41	26	68	10
Potatoes	26	13	48	2
Cotton	54	19	40	25

The continual planting of sugarcane exhausts the soil very rapidly, causing first a deficiency of nitrogen, then of phosphoric acid and lastly of potash.

Basset has compiled a mass of data regarding the composition of the sugarcane and of the various parts of the plant. These go to show that for every ton of canes harvested, 3·068 lbs. of nitrogen and 29·668 lbs. of mineral matter are, on an average, removed from the soil.

Taking Basset's calculations as a basis and disregarding those constituents which are present in sufficient quantities in all agricultural soils, we arrive at the following theoretical composition and proportions of the plant-foods removed by an average crop of 40 tons per acre :—

Nitrogen		122·72 lbs.
Mineral matters—		
Phosphoric Acid ...	99·80 lbs.	
Potash ...	366·40 ,,	
Lime ...	87·20 ,,	
Magnesia ...	69·40 ,,	
		622·80
		745·52

But if, as should be the case in any economical system of cultivation, the tops, and leaves and thrashing of the canes, and the skimmings and residues of the sugar-house be restored to the soil of the plantation, the lime and magnesia may, in the case of soils fairly rich in lime, be left out of sight, and the necessary provision of nitrogen, potash and phosphoric acid will be reduced to the quantities removed in the canes themselves.

Having recourse again to the data furnished by Basset, we find that these quantities are approximately as follows :—

Nitrogen	... ...	40 lbs.
Potash	... ...	80 ,,
Phosphoric Acid	...	37 ,,

Thus, on a careful but liberal estimate, in order to make provision for the production of a minimum crop of 40 tons of canes per acre, we have to supply to the soil of the plantation annually :—

Nitrate of soda (in two or more applications)		400 lbs.
Sulphate of potash	... ...	200 ,,
Superphosphate of lime ... (16 per cent. phosphoric acid).	...	300 ,,

Obviously, this formula must be modified to correspond with local circumstances of the soil and climate, and to the variety of cane grown.

From carefully carried out experiments of various manures in Java we can draw up a table of comparison concerning their efficacy for sugarcane :—

Fertilizers applied per acre. Plot	Weight of cane per acre in lbs.	Sugar obtained from 1 acre at 75% pressure in lbs.	Analysis of juice percentage of sugar per cent.
1. No fertilizer ...	41, 082	5,037	1904.

Fertilizers applied per acre. Plot	Weight of cane per acre in lbs.	Sugar obtained from 1 acre at 75 % pressure in lbs.	Analysis of juice percentage of sugar per cent.
4. Bonemeal 236 lbs. and sulphate of ammonia 178.	55,563	6,532	18·29
11. Earthnut cakes 1,180 lbs. and 393 lbs. acid phosphate (30 per cent.) ...	97,668	11,333	18·19
10. Earthnut cakes 1,180 lbs. and 315 lbs. sulphate of potash ...	110,103	11,097	16·23
16. The above and 393 lbs. acid phosphate ...	114,038	12,041	16·76
17. Earthnut cake only, 1,574 lbs. ...	125,056	12,277	15·19

Though the earthnut cake in large quantities gave an immense return in cane, it is particularly noticeable how low the percentage of sugar works out in the analysis of juice, whilst small quantities of bone, acid phosphates and potash show a very high return. As 1,180 lbs. of earthnut cake contain 18 lbs. of potash and 15 lbs. of phosphoric acid, it will explain how the percentage of sugar was not lower, and how beneficial it was to the growth of the plant. Plot 20 with potash and phosphoric acid added gave the highest return, viz :—
118,603 lbs. as the weight of the cane, against 114,667 lbs.

12,986 lbs. of sugar, against 12,592 lbs.; and 17·07 as the percentage of sugar, against 15·69.

Experiments in Honolulu with plant cane and first year rattoons gave, per acre, from different combinations of fertilizers :—

Results of experiments on plant cane harvested in 1899.

Kind of fertilizer applied.	lb. of cane per acre.	% sucrose in cane.	lb. sugar per acre.
Unfertilized ...	140,880	15·52	21,832
Nitrogen ...	172,040	15·12	25,463
Phosphoric acid ...	144,480	15·15	21,842
Potash ...	171,280	14·73	25,201
Phos. acid and nitrogen	170,040	14·41	24,466
Potash and phos. acid ...	170,120	14·73	25,041
Potash and nitrogen ...	182,200	14·95	27,230
Potash, phos. acid and nitrogen ...	171,520	14·89	25,493

Results of experiments on rattoons harvested in 1900.

Unfertilized ...	126,424	16·65	21,086
Nitrogen ...	174,636	14·10	24,631
Phosphoric acid ...	144,715	15·65	22,639
Potash ...	151,780	15·8	23,985
Phosphoric acid and nitrogen ...	210,161	13·53	28,463
Potash and phosphoric acid ...	153,063	14·55	22,272
Potash and nitrogen	222,134	13·85	31,008
Potash, phos. acid and nitrogen ...	221,297	13·30	29,265.

The fertilizer applied in the rattoon experiment furnished 182 lbs. nitrogen, 255 lbs. actual potash and 148 lbs. phosphoric acid, equivalent to 920 lbs. sulphate of ammonia or 1,137 lbs. nitrate of soda, 510 lbs. sulphate of potash and 1,000 lbs. acid phosphate. The most profitable combination was nitrogen and potash, which produced an increase of 9,922 lbs. of sugar over the unfertilized plot.

In Louisiana, cane is grown only on the alluvial soil, and its Sugar Experiment Station has concluded that a fertilizer, rich in nitrogen, with a small quantity of available phosphoric acid, is best suited to it.

The proportion of nitrogen is increased on rattoons and succession plant canes.

Throughout the Georgia and Florida Coast region a mixture of cotton seed meal, acid phosphate and kainit are almost exclusively used and produce good results.

Barbadoes finds nitrogen, preferably nitrate of soda and sulphate of ammonia, most effective. Phosphoric acid in acid phosphate, beneficial when used in moderation, diminishes the yield when applied in excessive quantities.

Demerara derives the most benefit from nitrogen as sulphate of ammonia, with Thomas Slag, the most effective source of phosphoric acid.

The Leeward Islands have, apparently, no great demand for nitrogen, although on soils not recently treated with pen manure its results are marked. Phosphates do not increase their cane yield, but in many instances decrease it, while potash with nitrogen gives the largest yields.

In a publication of the Imperial Department of Agriculture for the West Indies, Francis Watts shows that, on land where pen manure had not been previously used, an application of 60 lbs. of potash (120 lbs. sulphate of potash) per acre, produced an increase of 393 lbs. of sugar—2,318 lbs. of sugar, when nitrogen and phosphoric acid were added to the potash.

Another remarkable instance of the necessity of a proportion of phosphoric acid and potash in a cane fertilizer is the fact that when, instead of 1,180 lbs. earthnut cake, as in Plot 18 (Java Experiments) 1,574 lbs. were used on Plot 17, the yield of cane increased enormously to 125,050 lbs.; but, notwithstanding this increased quantity (10,389 lbs.) the production of sugar decreased by 315 lbs. Most sugar planters are well aware of the deleterious effects of nitrogenous manures in very large quantities unless counteracted by phosphoric acid.

The effect of phosphoric acid was especially noticeable in a field at Dinoy, experimented on by J. D. Kohrs, at the East Java Experimental Station in 1893:—

	Cane.	Sugar.
Without superphosphate ...	67,307 lbs.	7,429 lbs.
With superphosphate ...	89,353 ,,	9,409 ,,

Mr. H. Morrison of Hawaii reports in 1895 on the effect of fertilizers on sugarcane, and the figures speak for themselves:—

Plot 1. No fertilizer yielded per acre, 8,956 to 10,075 lbs. sugar.

,, 2. 13,434 lbs. stable manure, 13,434 lbs. sugar.

,, 3. 6,717 lbs. stable manure and 1,119 lbs. artificials (10 % phos. acid, 5 % nitrogen and 6 % potash), 14,553 to 15,172 lbs. sugar.

Besides the numberless experiments carried out in the West Indies, the Phillipines and Java, we have had experiments carried out in India by Mr. Mollison, now Inspector-General of Agriculture. Referring to these, the following letter from Mr. P. S. Kanethkar, the able and successful Superintendent of the Empress Botanical Gardens, Poona, puts the case clearly. He says:—"I forgot to inform you in my letter of the other day that I was one of those in charge of the experiments with making gul (raw sugar) from sugarcane fertilized with different manures at the Experimental Farm at Manjri, near Poona. The gul got from the bone manure plot was the best of all, golden yellow in colour, with sparkling crystals and as firm as could be desired. It kept dry in the monsoon when gul made from cane fertilized with poudrette and oil-cake manures generally gets pasty from the damp."

Irrigation is resorted to extensively and to very great advantage in the Hawaiian Islands and, as in Poona, it is relied on there as principle factor in the production of maximum crops. But it should be borne in mind that irrigation and the use of fertilizers are interdependent. With heavy manuring irrigation developes the productivity of the soil, but, if fertilizers are not applied in sufficient quantity, it helps to deplete the land of its plant-food.

It is doubtful if in many parts of India there is a sufficiency of cattle manure, and chemical, or rather, artificial fertilizers must be used to restore to the land the ingredients used by successive crops.

In the present state of our knowledge of the principles which govern the supply and utilization of plant-food, the sugarcane grower, like every other farmer, must turn for help to agricultural science and thus learn, at a minimum of cost, to maintain the soil of the plantation in such a state of fertility as to insure maximum and continuous yields and to combat the effect of unfavourable seasons, parasitic attacks, etc., by sustained vigour of growth. Prodigal and haphazard methods of manuring involve a waste both of capital and labour.

In the experiments on the Manjri farm, in former years, the attention of Government officials seems to have been fixed on ascertaining the amount of nitrogen required for the best crop of canes, forgetful of one or two points that require the most serious consideration from practical farmers, viz., the percentage of sugar obtainable from crops grown with an excessive amount of nitrogenous manure and of the waste entailed.

Such authorities as Messrs. Aitkin and Wright state that, in the question of manuring, the analysis of the soil is of less importance than the kind of crop. It has been proved by numerous practical experiments and observation that crops vary greatly in their power of utilising the several constituents contained in the soil. Some crops have a difficulty, in most soils, to provide themselves with enough nitrogen, others to obtain a sufficiency of phosphoric acid, while others, again, are unable to obtain enough potash. It follows that the substance that plants take up with the greatest difficulty is the one which exercises over them the greatest influence and produces the greatest increase of yield when applied to them in readily available forms in manure. The special requirements of the crop should have first consideration. The nature of the soil exercises only a secondary influence.

There are various sources from which the soil may be replenished and the crops provided with potash. In the first place, there is farmyard manure and also the manure produced on the farm by the consumption of cakes or other foods rich in potash. Were the supply of potash from these sources abundant enough and cheap enough, none other would be required. But, great as is the total quantiy of farmyard manure in England, it is not adequate for this purpose. The straw or litter of farmyard manure contains a considerable percentage of mineral plant-food. The ash ingredients in straw amount to 5 per cent. or about 112 lbs. per ton, of which 15 to 30 per cent. is potash. Taking the mean of a very large number of analyses of farmyard manure, it may be said that in the ash of well-rotted dung the amount of potash is from 4 to 7 per cent., that is to say, one ton of farmyard manure contains only from 9 to 15 lbs. of potash. Heiden calculates that 25 tons of farmyard manure, applied once in the rotation, would not suffice to restore the potash removed by an ordinary rotation of crops sold off the farm, even if every ounce of the potash in the manure were to find its way into the roots of the crops, which is not possible. More, probably nearly double that quantity, would be required to make good the loss.

If this is said of farmyard manure procurable in England and of ordinary crops, what must be said as to the deficiency in potash of Indian cattle manure when a greedy potash eater such as sugarcane is in question.

The growth of plants is regulated by the smallest quantity of any available and necessary plant-food. If the sugarcane is to reach its highest development, all the necessary plant-food must be ready in the soil. It was Liebig who formulated the principle :—" The plant does not live on single food ingredients but on a nourishment composed of different food-stuffs, and every single constituent part of this nourishment is effective only in the completed whole. Nitrogen cannot build a single leaf, a single stalk, a single halm, unless phosphoric acid is present and all other plant-food ingredients in sufficient quantity."

Professor Wagner says: "Nitrogen should, as much as possible, be carefully measured out for the plants, and only when the remaining plant-foods are present in sufficient quantities, is the best possible result obtained from the nitrogenous manuring, and the absorption of too great a quantity prevented."

The Hawaiians frequently use a ton or more of fertilizer per acre, applying it at two different times, first at planting, or soon after the cane is well up, and a second time at the opening of the following spring. Mr. Pogue of Kihei plantation has successfully applied nitrate of soda in the irrigation waters; as a question of economy, it is proposed to apply all soluble fertilizers in this manner. This practice is not unknown in Southern India.

In Louisiana, the amount of fertilizer used is 400 to 700 lbs. per acre. Nitrogen in excess of 48 lbs. per acre, which is about the limit of assimilation in an average season, has been found by the Experiment Station to be wasteful, and phosphoric acid at the rate of 36 lbs. ample. Fertilizers are usually applied at the time of planting, or at the time of throwing the first soil to the young cane, whether plant or stubble, by manure-distributing machines constructed to scatter the fertilizer on both sides of the row at the same time.

In Barbadoes 40 to 80 lbs. of nitrogen, preferably as ⅔ sulphate of ammonia and ⅓ nitrate of soda per acre, is correct, a small part applied shortly after the cane germinates and the remainder in June or August, when the cane's growth is most rapid, together with 80 to 100 lbs. of potash. Phosphates are not specially recommended, but, when used, should contain from 30 lbs. (on rattoons) to 40 lbs. (on plant-cane) of phosphoric acid per acre.

For Demerara's stiff clay 50 lbs. of nitrogen, in the form of sulphate of ammonia, with 500 to 600 lbs. of finely-ground slag phosphate, per acre, is considered about right by Professor Harrison. Both are supplied to plant-cane at an early period and in one dressing, but sufficient slag phosphate remains in the soil to supply the rattoons.

Generally speaking, the question of profit or loss in cane-growing turns on the intelligent selection of fertilizers, the correct use of which frequently doubles the yield.

The high esteem in which fertilizers are held by the Hawaiian growers may be inferred from the large quantity used annually. Director Eckart asserts that in 1901 no less than 25,000 tons of commerical fertilizers were added to the Hawaiian soils to satisfy the demand of the sugar industry. The shrewd business wisdom of this enormous consumption is made plain by the statement of Dr. Maxwell, that, where the trash of the cane is returned to the soil, each ton of sugar produced removes from the soil in cane :—

12·7 lbs. nitrogen.
35·3 ,, potash.
8·2 ,, phosphoric acid.

With the total sugar yield of the island approaching 300,000 tons on about 50,000 acres of land, the demand for this large quantity of fertilizers is apparent.

The secret of a profitable industry lies in economically growing robust cane, rich in sugar; and no soil is so rich as to continue year after to grow large, and remunerative crops, unless the plant-food removed by the crop be returned in the form of fertilizers. Those sugar countries, which are growing the largest crops of cane per acre are the most prosperous. A careful study of their practices teaches that they obtain success and wealth by thorough preparation of the soil, judicious fertilizing, intelligent cultivation (including irrigation when required) and in elimination of rattoons as soon as their yields drop below a profit-producing quantity.

The world's experience is that no one crop can be grown continuously and profitably on the same unfertilized soil, no matter how rich it was at the beginning. Sugarcane is a most exacting, as well as soil-exhausting crop. In a report recently made to the Queensland Government upon the condition of the sugar industry of Australia, Dr. Walter Maxwell, Director of the Sugar Experimental Station at Brisbane, emphasizes the necessity of feeding and so restoring to those soils their former fertility, which, according to the Hon. W. H. Groom, had fallen in annual yield from 40 tons of cane in the beginning to 16, 13 and 12 tons, in 1889, and according to the report for 1900 in North Mackay, to from 4 to 5 tons and in other districts to from 7 to 8 tons. Dr. Maxwell says: "The average yield of cane to-day throughout Queensland is 15 tons per acre as against 46 tons per acre during the earlier years of the industry." Further on, after showing by analyses of virgin soils and those continually cropped with cane a loss of 31 per cent. of nitrogen, 42 per cent. potash and 37·2 per cent. lime, in the latter, he adds: "Their immediate yielding power has been seriously impaired, but by more modern methods of cultivation, rendering available the reserve stores of plant-food and by returning to the land those elements which have been, and are being removed the producing power can be restored. Intelligent cultivation, and a judicious use of fertilizers can, without a doubt, restore the orginal producing power to these soils, and obtain 40 tons of cane per acre. More than that, here as elsewhere, by the application of scientific resources and intelligence, better and larger crops can be grown than those first produced by the virgin soil. Modern methods of farming and planting recognise the value of fertilizers for every soil and every crop, and the sugar planter, alive to the advantages of the present age, knows well that cane culture is among the most intense agricultural industries, where the size and profit of his crop is largely determined by the intelligent use of heavy applications of fertilizers."

As all the world over, so even in Egypt, a land of exceptional fertility, the constant cropping of the soil rendered it so poor that the harvests no longer paid the possessor or tenant for his ground-rent, rates, and taxes. Tiemann in "The Sugarcane in Egypt," writing on this point, says: "Can we succeed in getting more out of a given area than we have hitherto done? In any case plants will demand a good soil. And such a good and fruitful soil we can provide ourselves with, if we carry out the task, carefully employing the most practical instruments, and most suitable manure. The question then becomes, what manures should be employed? Stable-dung, natural compost manure, or artificial chemical manures? The answer is, use all together so as to achieve the best results. Stable-dung and compost manure can always be used yet do not sufficiently fulfil the claims of a nutrient, and in tropical and sub-tropical regions such as Egypt are not available in sufficient quantities. In artificial manures it is possible to have the three indispensable plant nutriments in properly proportioned quantities according to one's requirements. The artificial manures consist of nitrogen, phosphoric acid, potash and mixed manures. With artificial manure and stable-dung mixed together, the agriculturist will be in a position to double the crop output he has hitherto obtained and, in time, Egyptian agriculturists will be readily induced, for the sake of success to carry out their work with more care. and attention without the noted "malesh and bukrah" (" never mind " and " to-morrow"), and he who begins first will hold an advantage over his lazier neighbours. In a previous chapter it was shown what manuring mediums a planter had at his disposal in the country itself. The question now suggests itself whether the planter can supply the soil with its needed nutriments from these cited mediums so as to obtain a rich harvest on a par with those in other cane-growing countries. This is clearly not the case. The average crop of 550 to 600 cantars of cane per feddan (equals 22 tons per acre) and every statistical comparison with other tropical and sub-tropical countries shows the difference and deterioration in Egyptian results. Only from the view of momentary profit, is the ground drained by crops year after year without proper replenishing. In countries where unrestricted areas of ground are at one's disposal, and fresh tracts of virgin soil can be placed under culture, abandoning that portion which has become unfruitful, this may be excused, but in Egypt it is out of question owing to the limited strips of fertile soil, the high prices of land, and the dear rents.

In order to satisfy the high conditions of nutriment demanded by so ambitious, rich, and rapid growing a plant as the sugarcane, one must needs resort to artificial manures. No man dreams of carrying on the manufacture of sugar with century-old machines under present conditions of competition, and, similarly, it is a prime necessity for the planters to apply to the sugarcane the latest discoveries and methods of agricultural chemistry and technology. Agricultural Experiment Stations have for a long time past been working satisfactorily in Europe, America, and the East Indies; and Java, that standard country for raw cane-sugar, has practised for over 15 years a scientific system of cane-growing, as have in part also the East Indies. Yet, in general, the manuring of the sugarcane is still a little known and elucidated sphere of work. The figures relating to the crops and the results of experimental work show that Egypt's celebrated fertility is largely a thing of the past and yet, through careful methods of agriculture and by proper application of suitable manures, the present deterioration of crop yields can be superseded by good and lasting results. The stated quantities of mineral matter are absorbed from the ground by the canes in the course of a year and under the present conditions of agriculture are not returned to the soil. Even the leaves which were hitherto burnt in the fields now go to the factory to be used as fuel.

It only remains to consider the three chief plant nutriments—nitrogen, phosphoric acid and potash, and possibly lime. The remaining equally needful substances, on which the success of the plant depends, are generally present in the ground and in sufficient quantities and need not therefore be taken into account. The necessary carbonic acid is obtainable in inexhaustible quantities from the air. Moisture, air and oxygen are supplied to the soil by proper tillage. The percentage of lime present in Egyptian soils is mostly a good one. Yet the writer found on different occasions in the course of extensive experiments that very good results follow from a manuring of lime. The latter is not to be considered a manure, but it acts as a medium, in that it oxydises non-reactionary substances so as to make them assimilable. In the case of so-called black earth and acid soils a trial of lime manure is to be recommended. Nitrogen, phosphoric acid and potash are not in general available in sufficiently efficacious quantities in the soil as to allow the cane to achieve the best results and every prudent planter will supplement them by the purchase of artificials in definite amounts. Of the many forms in which these latter are placed on the market the writer considers the following the most suitable and profitable for the cultivation of cane on Egyptian soils :—

For nitrogen	...	Saltpetre.
For phosphoric acid	...	Thomas slag.
For potash	...	Potassium sulphate.

The nitrogen forms the motive power of the ground and effects a powerful formation of stem and leaf organisms and thereby a better assimilation of the remaining substances. The atmosphere in the tropics yields, under favourable conditions, more nitrogen to the ground than in colder regions. Its partial self-formation by means of the nitrogen-absorbing leguminosae was mentioned when describing green manures. Yet this does not suffice and, for supplementing it, saltpetre is more suitable than ammonium sulphate, owing to its direct action. With the existing conditions of irrigation it is likewise easier to work with the former without encountering any loss of available nitric acid. Experiments have also proved that saltpetre yields much better and more.profitable crop-results than ammonium nitrate, having regard to the cost of this latter manure. The ammonium must first change into nitric acid and then part of it is easily lost through the watering. In Java, for example, only ammonium sulphate is employed, because, owing to the subsequent heavy rains, the saltpetre would all be washed away. Thus the conditions are often different. In Egypt one applies the saltpetre direct in small quantities about two days after watering when the soil is yet wet, and one, two or three months after the planting, never later. In the interval of a fortnight, till the next watering, the plants have time to absorb fully all the saltpetre, and are thereby freshly invigorated for assimilating the remaining nutriments. It is merely a question of strengthening and supporting the cane in its early development as regards the sugarcane formation of absorbing organs, so that, by these and the absorbed nitrogen, the further building of cells and more luxurious plant growth can take place. Again, organic manures, such as blood mixture, meat meal, bone-dust, as well as pressed remains of oleaginous fruits may be employed, owing to their nitrogenous nature, but they are mostly unavailable in sufficient quantities, and are not cheap enough for great cultures.

Phosphoric acid is almost invariably a necessary supplement to the requisite substances for the favourable development of vegetation in Egypt. The employment of nitrogen alone in the case of the sugarcane brings about an apparently luxuriant vegetation but a weak unresisting cane stem, which is laid low by the first storm and is in general of little value for manufacturing purposes. On the other hand, if the supply of nitrogen is combined with that of phosphoric acid then one obtains a powerful, vigorous, resisting cane stem and a ripe sugarcane for the factory. By the action of the phosphoric acid the degree of ripeness and the sugar contents are specially favourably influenced. How necessary it is to constantly replenish the soil for the phosphoric acid drained from it, is shown by the following figures :—

During one harvest there are absorbed from each hectar of ground :—

Crop.	Per hectar phos. acid.		Kilos.	Per acre lb. phosphor. acid.		
Wheat	34·5	to	50·5	30·7	to	45·0
Clover	36·4	,,	52·0	32·4	,,	46·3
Cotton	50·3	,,	75·3	44·8	,,	67·1
Sugarcane stems	71·6	,,	120·0	63·8	,,	106·9
Sugarcane leaves	61·6	,,	103·2	54·9	,,	92·0

Potash forms one of the most important mineral matters which are absorbed by the cane and, in spite of that, its application has been hitherto a little solved question as regards its bearing on yields. The alluvial soil in Upper Egypt is not exactly poor in potash inasmuch as it contains about 0·5 to 1·5 of K_2O. As compared with this, the huge annual amount of 175 Kg. of K_2O, per hectar, is used up during each annual harvest, so that, sooner or later, scarcity of this food will ensue in the different cane-growing districts. As potash does not act by itself but only in combination with other substances, it is mostly difficult to obtain information as to its action, especially in the last few years, where unfavourable weather conditions have prevailed, so that the cane did not fully mature. The sugar content depends, in the first place, on the climate. In the case of those portions of land treated with potash increased quantities of the same mineral were found on analysis in the subsequent cane, a proof that the potash is assimilable by the cane. It is to be noticed in every case that, when fully manuring with nitrogen and phosphoric acid together, the corresponding application of potash has a particularly favourable result on the sugar content. In the case of cotton cultivation in the Delta, where the ground is of a similar constitution as that in Upper Egypt, manuring with phosphate of potassium has had pronounced results on the quality and quantity of the harvest. Sooner or later there will be a potash famine in Egypt, and it is therefore important to bear in mind, so as to protect this commodity from complete exhaustion. As potash manures for cane one must avoid chlorate products; sulphate of potash is the best form to employ where a substitute is required. In the other cane-growing lands, for example, Barbadoes—good results have followed a manuring with potash, and Professor d' Albuquerque considers the presence of potash useful to complete the manuring. He recommends the following :—

Nitrogen.	For first year cane per acre lb.	For second year cane per acre lb.
Two-thirds NH_42SO_4 / One-third $NaNO_3$	60	80
Phosphoric acid (For soil rich in lime) Superphosphate (For soil poor in lime) Basic slag	40 to 45	30
Potash	40	30

The amounts to be applied of these three chief nutriments and in what proportion so as to obtain the best results, depend in Egypt, as well on the local conditions. Here even the ground varies. One has to distinguish between black and yellow soils and naturally also the gradations of the same. The climate likewise varies in the long stretches of land from Cairo to Assiut. The preliminary crops and their rotation require as well to be considered. All this will be carefully weighed by a skilful agriculturist according to his experience, when discussing the question of manuring, without here going into details.

From experiments undertaken by the writer, and his observations during the last five years, he can recommend in general, the following manures for Egypt : In the first place nitrogen in combination with phosphoric acid has to be considered. The practical working of potash requires further elucidation than has hitherto been the case. The potash is possibly not everywhere of equal necessity. The amounts would be as follows :—

A. For the first year cane.		Per feddan. Kgr.	or per acre lb.
Saltpetre	...	75	185
Thomas phosphate	...	200	500
Sulphate of potash	...	50	125
B. For the 2nd year cane.			
Saltpetre	...	75 to 100	185 to 250

The Thomas phosphate and potash must be distributed over the surface of the fields on the occasion of the final ploughing and in calm weather. Moreover, we mix these manures with an equal volume of dry earth for better spreading.

Saltpetre is given in two applications as a top dressing 1 to 1½ and 2½ to 3 months after planting. In the usual case of planting in February, the end of March and the middle of May would be the periods. But for an early planting the first dose can be given at the end of January or beginning of February. The saltpetre should be distributed immediately after a watering of the plant rows, within a day or two of the irrigation water having settled down on the surface. It should be mixed with an equal volume of dry sandy soil. In this connection it must be observed that the potash should not be thrown on the young leaves, but laid on with the hand."

It is interesting to compare field experiments made in different parts of the world and to see the action of manures under varying climates, in soils bearing little resemblance to each other. Wherever these are carried out, one point stands out clearly, viz., that sugarcane thrives invariably and gives the best return when treated with complete and well-balanced fertilizers.

We extract a few remarkably telling results from Tiemann's experiments with concentrated fertilizers :—

Whilst unmanured cuttings give a return of	54,689	lbs.	per acre.
and	65,062	,,	,,
180 lbs. of Chili saltpetre produced	67,145	,,	,,
The addition of 180 lbs. sulphate of potash ...	71,269	,,	,,
The above *plus* 360 lbs. Superphosphate ...	75,478	,,	,,

the highest amount in the list of 26 experiments with various manures. The nearest approach to this high figure is to be found in experiment plot 18, where the fertilizers used were :—

360 lbs. superphosphate,
360 ,, sulphate of ammonia, and
2,100 ,, lime.

The absence of the potash in this manure is painfully apparent in the results, the total harvest being 71,483 lbs. Another remarkable result is shown in the use of Chili saltpetre, 180 lbs., the average weight per cane stem being the highest, but the outturn of sugar per acre was fifth in the list. No. 6, however, where a complete manure was used, though showing canes with an average weight 25th in the list, gave the 2nd highest return of sugar per acre. With the use of 180 lbs. saltpetre on plots 10 and 11, the outturn of cane was 39,861 lbs., with 360 lbs., the outturn rose to 49,185 lbs., but the percentage of sugar in cane fell from 14·2 to 13·9 per cent. In the series of experiments in 1899 one stands out so prominently above the rest that it remains a mystery why similar trials were not continued. Of 38 experiments carried out in that year there was one plot No. 2. fertilized with stable manure and bone-dust, the return from which was 80,913 lbs. of cane per acre, the nearest approach to it being plot 4 fertilized with 180 lbs. sulphate of ammonia (3 nodes) 73,034 lbs. the third, 72,170 lbs. being plot 19, in which every row was manured with :—

50 lbs. sulphate of potash,
50 ,, basic slag, and
35 ,, chili saltpetre.

Plot 6 also stood 2nd in the list of percentage of sugar in cane, having 14·5 against 14·91 % whose outturn per acre was only 66,739 lbs., the result of manuring with 160 lbs. of sulphate of ammonia.

We see clearly by an examination of the various experiments conducted in Egypt that a well-balanced manure containing nitrogen, phosporic acid and potash, invariably gives the best results and strengthens the conclusions arrived at by an examination of the experiments conducted in Java.

But more interesting to the natives of India will be the experiments carried out in the country with concentrated fertilizers. The decided difference between cane grown with the ordinary manuring, usual in the country, and such as was manured with concentrated fertilizers, is so striking that the mere views of the fields speak for themselves Unfortunately complete results were not obtainable.

Report No. 24, October 1st, 1904 :—

The experimenter writes as follows :—" I have applied to half an acre of wet land the fertilizer received from you in May last together with the usual cattle manure in plot 1. I was later by some 15 days than my neighbours in planting the billets. The plant is now 4½ months old and is doing remarkably well, there being a marked difference between this and other neighbouring plantations. Although the yielding has been hindered owing to the scarcity of rain and too much windstorm, I am happy to say the plants are fattening, with dark-green colour and canes bumpering. I shall be able to give you the exact outturn of the yield in March next, when I assure you many landholders who are watching the results of cultivation will come forward to manure their lands with your excellent fertilizers." The manure was made up of 16 cwts. groundnut cake, well ground, 1½ cwt. bone-meal, and 2 cwts. sulphate of potash, thoroughly mixed.

Another experimenter writes, under date July 10th, 1905 :—" I received your letter asking me to inform you of the actual outturn of sugar from my experiment, but I am sorry to say that I did not weigh my sugarcane.

My estimate for the half acre under experiment is 120 maunds. But other fields not manured with artificial fertilizers yielded only about 95 maunds. In this connection I ought further to inform you that the cane in the experimental field is a little affected by not watering in regular intervals. On this account a white pith-like portion was found in the middle of the cane, so I cannot state the real benefit derived by the use of this manure. Still I may say that it is an important benefit and it is a great boon to the raiyats."

In a land where nothing is known by the ordinary farmer concerning soil analyses, experiments with incomplete manures can be productive of little good. It was only in the year 1905-06, that the authorities of the Bombay Department of Agriculture decided to use other plant-food ingredients besides nitrogen.

The minimum nitrogen per acre was set down as 350 lb. This was determined, like the former 400 and 500 lb. by experiments with nitrogenous manures alone.

To these were added phosphatic and potassic manures, at the instance, if we are not mistaken, of the Agent of the German Potash Syndicate.

With 150 lb. potash added to the nitrogen the crop yielded 11,452 lb. of gul.

It was only when a complete manure was used that the return was most satisfactory, 13,044 lb. of gul being then obtained with 17·2 per cent. of gul to juice, and 13·4 of juice to cane.

The following table extracted from the report of Mr. J. B. Knight, M. Sc., Professor of Agriculture, Poona, shows clearly the excellent results obtained from artificial fertilizers in a district where heavy manuring is ordinarily resorted to with good cattle manure :—

Experiments at the Government Farm, Manjri, Poona, 1905-1906.

MANURIAL TREATMENT PER ACRE.	Quantity in lb.	Containing** N.	P_2O	K_2O	Cost of manures.			Number of canes.	Weight in lb. canes.*	Weight in lb. tops.	Weight in lb. juice.	Weight in lb. gul.	Cost of cultivation.			Net profit.		
					Rs.	A.	P.						Rs.	A.	P.	Rs.	A.	P.
1. Farmyard manure ..	44,876	350	..	..	90	0	0	24,450	40,368	6,888	28,000	5,096	221	11	4	118	0	0
2. Safflower cake ..	4,984	350	..	..	121	9	0											
Sulphate of potash ..	208	..	..	100	20	7	8	26,120	70,440	11,252	52,000	8,306	288	11	0	331	0	0
3. Safflower cake ..	4,984	350	..	..	121	9	0											
Sulphate of potash ..	312	..	..	150	30	11	6	30,420	86,476	16,972	68,000	11,452	318	6	8	445	0	8
4. Safflower cake ..	4,984	350	..	..	121	9	0											
Superphosphate ..	292	..	100	..	22	14	11	26,284	65,288	11,732	52,000	9,295	279	2	4	340	9	4
5. Safflower cake ..	4,984	350	..	..	121	9	0											
Superphosphate ..	438	..	150	..	34	6	4	30,088	86,740	15,444	68,000	11,876	307	11	8	484	2	1
6. Nitrate of Soda* ..	2,264	350	..	..	300	12	4											
Sulphate of potash ..	208	..	..	100	20	7	8											
Superphosphate ..	292	..	100	..	22	14	4	39,712	97,088	17,040	76,000	13,044	534	12	4	334	13	3

* In three dressings.

** N—Nitrogen.

P_2O—Phosphoric acid.

K_2O—Pure potash.

* Stripped and Topped.

It will be noticed that immense quantities of nitrogen are used in the various nitrogenous manures employed. The exact amount applied has been arrived at by experiments conducted under Mr. Mollison, whose energies were devoted to the elucidation of this question. But in dealing with it he was satisfied evidently that nitrates and nitrites were all that was needed. The *law of minima* was totally neglected. Potash and phosphoric acid in conjunction with nitrogen were apparently not thought of. By the application of such large quantities of nitrogen there is no doubt that a great deal is lost in the drainage. What nourishes the plant must do so only when there is a sufficiency of phosphoric acid and potash, and unless these are placed in the soil in the necessary proportions the land must necessarily be denuded of them. Yet in the Report of the Manjri Farm for the year 1908-09, we find a return to the old story of combinations of various nitrogenous manures, with this difference that the cost is no longer considered and not one of the six experimental plots in this series shows a profit. In 1905-06, notwithstanding the great cost of the manures, ranging from Rs. 90 in the case of farmyard manure to Rs. 344, in the case of the complete fertilizer, the nitrate of soda of which alone cost Rs. 300, the profits ranged from Rs. 118 to 484. In this year's experiments, where no superphosphate is used, though the cost of manures is only Rs. 118, the loss totals Rs. 129. The use of superphosphate, in a complete fertilizer raises the cost of the manure by only Rs. 5, but the difference in the results amounts to Rs. 178, showing a small net profit of Rs. 49. Safflower cake was used in all these experiments in addition to farmyard manure, and 350 lb. of nitrogen still remains the minimum.

Under the rotation experiments appearing in the report for 1909-10 it seems plain that nitrogenous manuring alone is to be continued. The treatment per acre was 45,100 lb. of farmyard manure at planting, and 2,588 lb. of safflower cake, the value in each case being Rs. 169· The profits range from Rs. 268 to 317. Every experiment, whether with nitrogenous manures alone, with nitrogen and phosphoric acid, or with the above and an addition of potash, appears to have paid and paid well, the complete manure consisting of 39,600 lb. of farmyard manure, 2,127 lb. of safflower cake, 305 lb. sulphate of potash, and 239 lb. superphosphate, giving the highest return of gul and the highest net profit.

At last there appears a chance of seeing the heavy manuring with nitrogen reduced. On three plots fertilized with 250, 300, and 350 lb. of nitrogen per acre respectively, we find the profit on the 250 lb. plot only Rs. 5 less than that of the 350 lb. plot, and Rs. 35 less than the 300 lb. plot. Unfortunately there were no check plots, or the experiment would have been more interesting and likely to lead to more conclusive deductions. It is a pity that in all these experiments to determine the smallest quantity of nitrogen that will result in the best crop, the simple method of using complete fertilizers is scarcely ever resorted to—in fact, seems to be carefully avoided as if the experimenter were afraid of bumping against the solution of the problem.

From experiments in Java we find far smaller quantities of nitrogen in nitrate of soda and sulphate of ammonia used, but what strikes one throughout these experiments is the very small increase in the weight of the canes with the increase of the nitrogenous manure beyond a certain point and the decided falling off in sugar in many instances.

In 1893 at the Experimental Station, Ketegan, Mr. R. J. Bouricius tabulates results as follows :—

		Pro hectar. Weight of canes.	Sugar.
Unmanured		81,374 Kg.	10,422 Kg.
Sulphate of ammonia	176·5 Kg.	91,817 ,,	12,684 ,,
Do. do.	353·0 ,,	117,056 ,,	13,098 ,,
Do. do.	529·5 ,,	120,538 ,,	13,098 ,,

It will be noticed that an increase of 176·5 Kg. of sulphate of ammonia, used alone, though it resulted in about 3,000 Kg. more of cane, produced no more sugar.

From Mr. Pohdjedjer's Sugar Factory we have results still more pronounced :—

		Pro hectar. Weight of canes.	Sugar.
Unmanured		73,541 Kg.	8,834
Sulphate of ammonia	176 Kg.	99,041 ,,	11,001 Kg.
Do. do.	353 ,,	112,879 ,,	12,968 ,,
Do. do.	529 ,,	99,824 ,,	12,811 ,,

It is just as evident in the report of Mr. Kloerahan's Sugar Factory :—

Unmanured		106,091 Kg.	9,086 Kg.
Sulphate of ammonia	176 Kg.	117,8[illegible]0 ,,	10,069 ,,
Do. do.	353 ,,	119,841 ,,	9,626 ,,
Do. do.	529 ,,	120,190 ,,	9,469 ,,

In the Manjri experiments, even if such quantities of nitrogen were continued, it is a pity that in the combinations with phosphoric acid and potash, oil cakes were not till now tried as the nitrogen supplying material. This *would have reduced the item under "cultivation" considerably* and increased the net profit to a very great extent. We are pleased to find their benefits have been shown in the 1909-10 Report.

At the same time we do not consider the amount of nitrogen fixed as the best paying quantity as correct, for, it is far in excess of the needs of the plant, and would suggest that varying amounts of nitrogen, ranging from 100 to 250 lbs. should be tried in future, not alone, but in combination with phosphatic and potassic manures.

In the learned and interesting work of Professor Dr. H. Wilfarth *in conjunction with* Dr. H. Roemer and Dr. G. Wimmer *on "The Assimilation of Foods by Plants at Different Periods of their Growth," we find* reports of the most carefully conducted pot and plot experiments and the conclusions drawn from them. Speaking of potash and its effects on plant-life, the authors say :—"With the want of potash the production of carbohydrates invariably falls and the fall is greater, the greater the deficiency in potash ;" and a little later :—"It is known that the carbohydrates made in the assimilation process are used only partly in building up the plants, that to a great extent they are decomposed by the necessary exhalation and are thus lost to the plant. Is it not possible that inorganic parts meet with a similar fate? Is it not also possible that a part of this stuff, even when it is not directly used for the building up of the plant, may be necessary for its life and growth, and finally, when the plant has fulfilled all its functions, may become superfluous, just as the animal organism does not by any means use all the materials it consumes?"

In all parts of the plant the quantity of nitrogen lessens towards the end of the period of vegetation except in the grain in which the reserve stuff remains. The same occurs with reference to potash. This cannot be due to the decayed leaves, for a loss of 1% of potash would mean 40 cwt. per acre and as this is out of the question, the only conclusion we can come to is that in the case of barley, for instance, as in the other experiments under record, the potash taken up by the plant is not fixed in the form of an insoluble organic substance, but in a manner in which it can move about, going through a physiological process within the plant and, having performed its functions, returning to the soil through the roots as the plant nears its death.

Nitrogen, phosphoric acid and soda are not of so much importance in the building of carbohydrates; for even when there is a great deficiency in nitrogen we find the contents in starch and sugar very high, and even where the deficiency in phosphoric acid is decided the loss of starch and sugar is very small. Potash plays the cheif role in the origin of the latter, for, as soon as this is wanting, the formation of carbohydrates falls with the failure of potash. Consequently every plant requires a certain quantity of potash to produce a maximum of carbohydrates.

When nitrogen and phosphoric acid are deficient the weight of the harvest is lessened, but the quality of the plants especially the fruits and tubers, and the relation of the various parts of the plant to one another are little changed, and if the deficiency in nitrogen is not too great, the quality appears to be even better. When, however, there is a deficiency of potash, profound changes occur and the relation of the single parts to one another alters in a way very different from that evident in the case of a deficiency in nitrogen and phosphoric acid; the exterior form of the plant suffers decided changes, and the building of carbohydrates lessens with the increasing deficiency in potash. It is noticeable, from these experiments, that, when the allowance of potash was the smallest, the greatest amount of potash, viz., 40% of that taken up by the plant, returned to the soil, whilst when the greatest amount of potash was placed at the disposition of the plant, the return to the soil was the smallest, viz., 16%. It must be of the greatest importance in the question of manuring to judge the right quantity of potash that should be placed at the disposition of the plant."

What is most striking in these experiments, made by the most learned and painstaking scientists in Germany, is the near relation found between the return of nitrogen and potash to the soil and the dependence of the increase in the return of nitrogen on the deficiency of the potash supplied. We have seen before that there is a loss of nitrogen as the plant nears its maturity. It is clearly brought out in the book under reference that the contents in nitrogen at the harvest are higher with the increased application of potash. With the lowest application of potash the loss of nitrogen was 27%; with the largest, the loss had sunk to 10%. This agreement in the action of potash and nitrogen is worthy of attention. In conclusion, the authors remark:—" In all similar field experiments made by other authors similar results have been obtained."

It is to be hoped that experiments on similar lines will be begun, directed from Pusa, at the Manjri farm, Poona.

In the sugar-growing district of Poona it may help to settle the question of the requisite amount of nitrogen to be used per acre when a sufficiency of potash is available.

Experiments on Mr. Morrison's plantation in Hawaii in 1895 may serve as a basis for future trials in Poona.

Manure per hectar.	Sugar per hectar.
1. Unmanured	10,040 to 11,295 Kg.
2. 15,060 Kg. farmyard	15,060 Kg.
3. 7,530 do. 1,255 artificial manures containing 10% phosphoric acid. 5% nitrogen. 6% potash	16,315 to 17,570.
4. 1,255 Kg. artificial manure as above without farmyard manure	15,060.

Of the various pests that harm the sugarcane, the most destructive is the borer moth. Watt in the "Dictionary of Economic Products in India" seems to have touched the spot, when he remarks:—"Various authors allude to insect pests as following mostly on the track of defective cultivation and as often doing serious damage."

Perhaps, the greatest fault committed is the continuous cultivation of the same crop year after year in the same holding. Babu Jaykissen Mukarji says that in places where the Mauritius red canes were planted earliest, viz., about 20 years ago (Journal Agri-Hort. Soc., IX, 355—358) the disease appeared slightly about two years ago. Last year the decay increased and this year total destruction has taken place. Where this cane has been introduced only lately or 10 or 15 years ago, though they have somewhat suffered this year from excess of rains, yet they are free from the disease. In the lands of the Burdwan Districts bordering on the Hughli a similar result has taken place.

The disease and its calamitous effects have been repeatedly witnessed in India and are known in Java and some of the British Colonies. The canes become attacked by a worm, and, when in that state, emit so offensive a smell that the fields cannot be approached.

It is admitted by all sugarcane planters that continued propagation from cuttings grown year after year in the same soil results in a serious degeneration. This same fact is fully appreciated by the native cultivators of India and the danger of too continuous a cultivation of any particular form is quite understood.

Hitherto the necessity of rotation has been put down to the question of food-supplies of which the same crop deprived the soil; but, from the experience of beet growers in Germany, where scientific agriculture is at its highest, we find that manuring alone will not suffice, but that rotation or fallow must be resorted to, or failure of the crop is bound to follow. The same is seen in what English Agriculturists term clover sickness. The question of a falling off in results from orchards overrun with grass is yet a puzzle to the British Association. Yet all may possibly and very probably be explained by what Jaeger has tried to prove, a theory that will soon be an axiom in agriculture, viz., that the exudations or excreta from the roots of the plant, when overconcentrated, cause sickness and death just as the overconcentrated effluvia from animals act upon their health. In the case of men it is recognised as the alphabet of hygienic science and it will soon be recognised as an axiom in agricultural hygiene also. A cure will probably be the very remedy used when dealing with human and animal excreta.

If rotation cannot be resorted to, other means may be easily obtained to combat the disease. It is now pretty generally admitted that pests though they may occasion disease, are themselves attracted to plants already suffering and Mr. O'Reilly writing to the Agri-Horticultural Society all but points to the cure:—" I find he says, that by placing a good layer of common charcoal from the furnaces under all materials of wood subjected to the ravages of white ants they are well preserved and in no case have I discovered any damage when this precaution has been taken."

This natural deodoriser will prove a remedy against the disease to which cane is subject, when grown constantly on the same land, provided a sufficient supply of well-balanced fertilizers are used, and I have no doubt the same remedy will serve against the potato blight, clover sickness, and similar diseases that arise when rotation is not or cannot be effected.

On this subject I propose writing at greater length on some future occasion. It may seem a remedy as cheap and ridiculous as the theory itself appears, but no true scientist merely laughs at a theory when nothing else has yet explained a difficulty, and it is to be hoped that experiments to prove this will be undertaken, especially in India where the peasants can so ill afford to let good land adjoining their villages lie fallow.

Green manuring may also be tried with profit. According to Mr. Wray (*vide* Watt's Dictionary of Economic Products) the Chinese planters in the Straits often obtain excellent crops from a soil so sandy and otherwise unfertile that no European planter would for a moment think of planting canes in such lands. This result is obtained by placing the stems and leaves fresh from the indigo vats over the roots of the cane and then moulding over them.

But the native farmer is a perfect judge of leguminosae and probably understands more of the likes and dislikes of plants than any of his European brethren. It is not only as a manure these are recommended but to ascertain which of them will serve as a deodoriser to the soil and which prove most agreeable to the sugarcane. Besides this, more attention should be paid to commercial fertilizers to supplement or take the place of natural manures.

Woodrow, speaking of the soil of Poona, says it contains very little of the silica in combination with potash of soda and lime, in the form known as soluble silicates, without which sugar cannot grow, and he suggests the use of ten loads an acre of wood-ash and to sow and plough in a green crop. If to this were added Mr. Ozanne's recommendation that the bones now exported to Europe should be crushed and used in the cane fields, a perfect manure could be made up. But superphosphate, or for Hindus, who object to use the bones of animals, Basic Slag might supply the phosphoric acid, and in place of so many cartloads of ashes, which cannot be readily obtained, a bag of sulphate of potash would suffice. Instead of wasting their energies on the acclimatization of exotics as appears to be the case whenever the Agricultural Department wished to make an improvement, it would be infinitely better if a serious attempt were made to improve the indigenous crops of the country by the application of commercial fertilizers—a thing done by every Experiment Station in the civilised world beyond the borders of India.

I shall conclude in the words of George Watt, M.B., C.M., C. I. E., Reporter of Economic Products with the Government of India, Officer D'Academie, Fellow of the Linnaean Society, etc. :—" It seems to be the prevailing evil tendency of agricultural reformers to look to countries outside India for new economic products or superior races of existing crops. A state of indebtedness in these matters must necessarily mean the absence of the vitality essential to progression. Witness the load laid by its pioneers on the tea industry through the importation of the Chinese plant. It was not until the so-called indigenous tea was taken in hand and the Chinese stock largely exterminated that tea-planting gave indications of success. Witness also the extravagant waste of money in the attempt to bring back to India the Carolina development of rice. The improvement by insidious adaptation of the indigenous stock may be less rapid (and hence by no means so attractive to the individual reformer) than the importation of a perfect race, but the result is more certain and the accomplishments, however slight, are permanent and direct gains. The failure of the past attempts at establishing in this country, sugar-cane plantations, at a time when India might (at least along the more direct routes of export) have had reasonable expectations of success, may, to a large extent, be attributed to the chief effort having been directed towards the vain pursuit of methods by which, to perpetuate, under the vastly different conditions of India, the special peculiarities of certain races of cane which had been brought to their perfection in the West India Islands. The idea of using the Indian forms of cane was only embraced when the industry was on the eve of expiration, or, at all events, when it had wasted fruitlessly its best opportunity."

TOBACCO.

QUALITY, SOIL AND MANURES REQUIRED.

In treating of tobacco it is not sufficient to restrict one's self to the question of manuring, for so much depends upon the soil in producing tobaccos of different market values, and the price rests still more on the treatment of the leaf after the harvesting. The analysis shows in a thousand parts:

Water	180	Magnesia	17·7
Ash	151	Phosphoric Acid	4·8
Potash	30·3	Sulphuric Acid	5·8
Soda	5·1	Silicic Acid	13·5

According to the analysis of the ash of the Havanna Cigar by A. Percy Smith (Chemical News, XXVIII 261, 324), it contains:—

Potassium Sulphate	7·401
,, Carbonate	9·012
Sodium Sulphate	5·764
,, Chloride	3·272
,, Carbonate	1·039
Calcium Sulphate	4·180
,, Carbonate	45·400
Ferric Oxide and Phosphoric Acid	0·460
Calcium & Magnesium Phosphates	9·210
Silica	9·641
Charcoal	3·162
Aluminium Lithium Carbonate	1·459

In Mr. Johnson's "How crops can grow," p. 378, we have the average of all trustworthy analyses of the ash constituents of tobacco, published up to 1865. Average percentage of ash 24·08 consisting of :—

Potash	27·4	Soda	3·7
Lime	37·0	Magnesia	10·5
Phosphoric Acid	3·6	Chlorine	4·5
Sulphuric Acid	3·9	Silica	9·6

When, with this, we compare the poor quality of good Indian tobacco grown at Buldana, the analysis points to the absence of the necessary carbonate of potash and the superabundance of chlorides so common throughout the country.

Dr. Lyon analysed it thus :—

Potash	1·73
Chloride of Potassium	15·82
Oxide of Iron and Aluminium	13·31
Lime	30·65
Carbonic Acid	2·08
Magnesia	5·89
Sulphuric Acid	3·68
Silica	26·84
Phosphoric Acid	traces
	100·00

Percentage of ash 21·28

But as the whole plant requires f[illegible]d, the stalks and mid-ribs, which may possibly be, but are not always returned to the soil, should also enter into the analysis.

According to Professor Stockbridge, the average Florida plant shows :—

Nitrogen 2·58, Phosphoric Acid 0·99, Potash 4·34.

Dr. Jenkins calculated that an average Connecticut crop removed from the soil :—

Nitrogen 100 lbs., Phosphoric Acid 16 lbs., and Potash 150 lbs. Two of the substances standing out prominently in the analyses are lime and potash, and we find that the best producers of tobacco invariably supply potash in large quantities, since the plant demands a greater amount of this food than most other crops. Lime is seldom added to Indian soils without doing harm, but potash is often wanting, especially where tobacco is grown in this country, and potash is of the greatest importance for the tobacco crop, not merely for the quantity but more especially for the quality. From the analysis we see that the mineral matter taken from the soil by the tobacco plant amounts to about a quarter of the weight of the dry leaf. The greater part of the ash consists of insoluble salts, principally carbonate of lime, and the soluble part, largely of potash salts, which may amount to from 5 to 35 per cent.

Cultivation experiments show that chloride of potassium used as a manure does not add to the organic potash salts in the leaves, but the sulphate, carbonate and nitrate do give up their potash for the formation of organic salts. It was Schlossing, who, in 1860, showed that the good burning qualities of a tobacco depend upon the potash it contains in combination with a vegetable acid. The analyses since made go to prove the truth of this, and that it is the carbonate of potash, which is the chief constituent effecting combustibility and certainly improving its flavour.

The whiteness of the ash is due also to the salts of sodium as well as to those of potassium, as they cause the fibres to tear while burning and thus induce complete combustion.

If tobacco burn badly and with a dark ash, we may be sure that the soil was deficient in carbonate of potash. Such soils will never grow good tobacco. Not only must potash be in the soil, either naturally or by manures, but it must be present in an easily available state and in ample quantities, as tobacco is an exhaustive crop and requires a rapid and abundant supply of its ash constituents, and of ammonia. Reporting, in 1871, on exotics experimented with in India, Dr. Forbes Watson says, of the crops obtained from Shiraz and Havanna seeds in the Bombay Presidency, that the tobacco plants grown from different seeds on the same soil will possess substantially an identical composition as regards their mineral constituents. "I should next draw attention," he continues, "to the relatively large amount of chlorides in the tobacco. It is possible that this is due to the presence of chlorides in the manure, etc. used. If so, it affords a proof of the facility with which the tobacco plant alters its mineral constituents according to the nature of the soluble matters present in the soil on which it is grown, and showing its susceptibility to treatment, holds out hopes of our being able to improve the mineral constituents of the plant in any desired direction by properly apportioning the soluble matters of the manures employed. It would be worth while, I think, to conduct a few experiments, something in this way. Samples of the same variety of tobacco might be grown on the same soil under the influence of different manures, subjected to the same process of curing and then submitted to analysis. This appears to me a likely method of improving the quality of the tobacco. The curing process might also be varied with a view of ascertaining the effect of alterations in it on the percentage of nicotine."

The leaves when well dried should contain a minimum of 5 per cent of potash.

So long ago as the year 1867, Professor Nessler was convinced that the manure used had much to do with the quality of the leaves as well as with the quantity. By careful trials he found that the duration of the glow continued with the increase of the potash in the leaf, and diminished when the percentage of chlorine was great. Of course these, though important factors, are not the only causes that affect the combustibility of the leaf. He records the following experiments:—

Percentage of Potash.	Percentage of Chlorine.		Duration of glow in seconds.
4·0	0·40		25 and over
3·5	0·22	from	13 to 24
2·8	0·67	,,	8 to 10
2·2	0·73	,,	4 to 7

The question was taken up in 1891 by the German Agricultural Society, the Potash Syndicate, and the Mannheim Tobacco Combine, as well as by various German States, and experiments begun on the Darmstadt Experimental Station, both in pots and in the field. The results showed that plants receiving very little or no potash as manure showed only from ·51 to ·70 in the leaves, that such as were over liberally supplied with potash, contained as much as 6·15 per cent potash calculated on the dry substance, but the largest yield was obtained from a manuring that produced only 2·3 per cent potash in the leaf.

The average of the very great number of experiments with reference to the duration of glow of the fermented leaves made by Wagner, confirm the decisions previously arrived at, that the duration increases with the increase of the percentage of potash in the leaves. Had the amount of chlorine been also taken into consideration in these experiments, many apparent discrepancies would probably have been explained. This, however, is clearly brought out in the experiments on the combustibility made with nineteen samples, which were sent for examination by the United Lankat Plantations Company, London. These prove clearly the statement of Wagner that "as a rule, the tobacco leaves must contain at the very least 5 per cent. and if possible, 6 per cent potash, and not more than 0·6 per cent chlorine, calculated on the dry matter, if the fundamental conditions of a perfect 'burn' are to be fulfilled."

Professor Wagner, in his experiments on the burning quality of tobacco, brings out clearly the increase of burning power with the increase of potash in the leaf. An interesting table from his work follows :—

Experiments.	No. of seconds the tobacco burned.	Dry substance contents in potash.	chlor.
1	3-4	5·5	3·0
2	3-4	3·6	2·9
3	4	4·0	3·2
4	8	2·8	0·4
5	10	4·4	1·0
6	29	6·5	0·3
7	29	7·6	0·4
8	60	6·2	0·7
9	60	6·6	1·2

Tobacco is one of the most profitable crops grown in tropical and sub-tropical countries, and India is one of the most important tobacco-growing countries of the world, the acreage under it being about 2,000,000 acres, though the quality is very inferior. The only chemical deficiency of Indian tobacco, according to the result of several analyses, is in carbonate of potash, proving the poverty of Indian soils in this important plant-food.

At Kentucky, U.S.A., various experiments were made with fertilizers both incomplete and complete. Muriate and sulphate of potash gave equally good results, though we are inclined to recommend sulphate, which does not contain common salt. Nitrate of soda produced a better quality of leaf than other forms of nitrogen. Of complete fertilizers :—

80	lbs.	of nitrate of soda
80	,,	dried blood
160	,,	Muriate of potash
14	,,	Double superphosphate

produced 1,460 lbs. of cured leaf. By doubling the quantity of fertilizer the yield of leaf was increased to 1,620 lbs.

Although we find so little phosphoric acid in analyses of the plant we learn from experience that a good supply of this plant-food ingredient is decidedly beneficial. As with a number of other plants, the action of phosphoric acid and its absorption, assimilation, and excretion by plants is yet little understood, and we look forward with great interest to the forthcoming experiments and researches on the subject of Professors Wimmer and Roemer of Anhalt (Germany).

As to the proportions in which fertilizers are to be mixed there is, and will be, a deal of divergence, but many planters use plant-foods in the proportion, nitrogen $1\frac{1}{4}$, phosphoric acid 1, and potash 2, and the best Connecticut Valley growers, who depend solely on fertilizers, use for growing tobacco year after year on the same soil from 1,500 to 3,000 lbs. of this mixture. For India a manure made up the following mixture would probably produce excellent results :—

Cotton seed meal or castor cake meal...	8 cwt.
Sulphate of potash ..	3 ,,
Bonemeal or superphosphate	2 ,,

Bone is preferable, for the sulphuric acid in superphosphates is considered injurious when present in excess, and in a warm, moist country, bone is by no means a slow-acting manure.

At Calhoun, on red sandy and grey sandy soils, nitrogen in the form of nitrate of soda, cotton seed meal, or dried blood, caused a marked increase in the quantity.

The best quality of leaf was obtained by a mixture of cotton seed meal, superphosphates and sulphate of potash.

In experiments made in Virginia, dried blood for nitrogen gave the largest yield and the best financial returns, and in all cases, the tobacco ripened from ten days to two weeks earlier on the fertilized plots.

In Deli, Sumatra, where the tobacco grown has obtained a world-wide fame, the beds are highly fertilized with rich manures, a complete guano or complete specially prepared fertilizer (artificial), and on old lands, to ensure safety against grass and weeds and to add potash to the soil, the land is burned over and the soil enriched by the ashes, and perhaps deodorised by the charcoal and the heat.

In Trincomalee (Ceylon) sandy soils are chosen, and compost from dunghills, or dry powdered cattle dung is used. Wherever tobacco is grown stable manures are commonly employed, but it is everywhere admitted that fertilizers known to be rich in potash are especially to be recommended. In many parts of the United States of America it is customary to apply specially prepared fertilizers after the plants have attained considerable size, to still further stimulate the growth of the crop.

There are two sets of experiments with various fertilizers, carried out by Wagner, which are of the greatest interest to the tobacco-grower who wishes to get the best returns as to qual ty and quantity for the money he expends in raising his crop, as every intelligent farmer wishes to do. The first series was conducted with artificial fertilizers only, the second with artificials, with cattle manure, and with a combination of both.

No.	MANURE.	Containing.			Leaves (dry)	Increase over unmanured.	Potash % in leaf.
		Phos. Acid.	Potash.	Nitr.	cwt. lbs.	cwt. lbs.	
		lbs.	lbs.	lbs.			
1	....	..	..	..	12—36	..	4·07
5	2 1/3 cwt. superphos .. 2 1/3 ,, sul. potas. ..	42¾	133½	..	12—89	0—53	5·18
4	2 1/3 cwt. superphos. .. 1 1/6 ,, sul. ammon. ..	42¾	..	26¾	13—13	0—89	4·93
2	2 1/3 cwt. superphos. .. 2 1/3 ,, sul. potas. .. 1 1/6 ,, sul. ammon. ..	42¾	133½	26¾	14—16	1—92	5·93
3	2 1/3 cwt. sul. potas. .. 1 1/6 ,, sul. ammon. ..	..	133½	26¾	14—25	1—101	5·84
6	2 1/3 cwt. superphos. .. 2 1/3 ,, sul. potas. .. 3/8 ,, ammon nitr. ..	42¾	133½	26¾	15—25	1—101	5·88

Here we note that, though one of the experiments with an incomplete manure shows as good a return as one of the plots treated with a complete fertilizer and even 9 lbs. more than with another, the percentage of potash is greatest in the leaf, in the complete manures, and practically both for quality and quantity it pays best to use fertilizers containing all the constituents of a well balanced plant-food.

The result of the second series is as follows :—

General Manuring per Acre.	No. of Plot	POTASH MANURES	Containing. Potash lbs.	Containing. Chlorine ozs.	Yield of Dry Matter per Acre. Stalks cwt. lbs	Yield of Dry Matter per Acre. Leaf cwt. lbs.	Amount in the Dry Matter of the Leaf. Potash per cent.	Amount in the Dry Matter of the Leaf. Chlorine per cent.	Potash in the leaf. lbs.	Duration of glow of fermented leaves. Seconds.
2½ cwt. superphosphate ..	1	....	..	..	14--7	11—86	2·946	0·256	39	23
	2	2½ cwt. sulph. potas.	133½	8½	13--57	11—86	4·083	0·520	54	45
1 1/6 cwt. sulphate of ammonia ..	3	4½ ,, ,, ,,	267	17	13—30	11—86	4·300	0·675	57	50
	4	6 3/4 ,, ,,	400½	24	12—107	11—86	4·974	0·832	66	54
	5	8½ cwt. Silicate of pot.	133½	..	13—92	11—60	4·346	0·410	56½	47
16 tons farmyard manure ..	6	....	..	..	12—72	12—27	4·145	2·905	57	20
	7	....	..	..	11—79	12—98	3·750	2·448	34½	21
16 tons farmyard manure. ..	8	2½ cwt sulph. potas.	133½	8½	1 —19	12—107	4·451	2·307	65	33
	9	4½ ,, ,, ,	267	17	11 104	12--98	4·603	2·318	67	42
2½ cwts. superphosphate ..	10	6¾ ,, ,, ,,	400	24	11—69	13—48	5·380	2·824	81½	36
6 1/6 cwts. sulphate of ammonia ..	11	8½ ,, Silicate of pot.	133½	..	11—60	13—30	4·592	2·330	68½	41

It is more interesting to Indian farmers, for we have trials with farmyard manures with which to make comparisons. It is worth noting in the first five experiments :—

(1) That the plots treated with incomplete fertilizers produced no more leaf than the unmanured plot and considerably less weight in stalks.

(2) That the percentage of potash in the dry leaf was nearly double that found in the leaves from the unmanured plot.

(3) That though the chlorine in the manured plots showed a percentage of chlorine between 3 and 4 times that in the unmanured leaf, in only one case did it go above 0·675. Though it reached 0·832 in this case, the potash percentage was so high that the burning did not appear to be much affected thereby.

(4) That with the increase of potash in the leaf the burning quality increased, the duration of combustion lasting, in the case of the fertilizer plots, twice as long as it did in the case of the unmanured plot and Nos. 6 and 7 which were treated with cattle manure alone, 16 tons being applied per acre. In these we find the weight of stalks decrease considerably and the weight of leaves rise proportionately above the plots manured with incomplete fertilizers : but the percentage of potash contents of the dried leaf also falls, whilst the chlorine rises to 2·448 and 2·905, bringing down

the duration of glow below even that of the leaves from the unmanured plot.

The use of a complete fertilizer together with 16 tons of farmyard manure, produces a fall in the weight of stalks and a decided increase in the weight of leaf, raises the amount of potash in the leaf but does not, to any extent, decrease the chlorine, with the result that the burning quality suffers and the duration of the glow is very much less than that found with the leaves of the plots not treated with cattle manure.

It is evident that the deleterious effect is due to the chlorine, of which no small quantity is to be found in farmyard manure. Another point in evidence is the fact that with the increase of the sulphate of potash in the manure, there is a corresponding increase in the potash contents of the leaf. By the use of larger quantities of silicate of potash there is not a corresponding rise, but rather a fall in the potash contents, yet as this is accompanied by a corresponding fall in the chlorine contents, the burning power is not diminished. The advisability of its employment must depend upon its price.

The points to be considered in cultivating tobacco are so many that the crop requires most careful attention, as regards climate, soil and manures, to produce burn, taste, aroma and texture of leaf, and the cutting, drying, sorting, and curing must be in the hands of experts, if the best possible return is to be obtained. Speaking of Ceylon tobacco Mr. A. MacDonald Gibson, an expert from Borneo, says:—" The full natural flavour of the tobacco ought to be retained, the colour of the leaf improved and the tobacco generally cured so that it will keep any length of time. The native system tends rather to destroy the leaf while it renders it as black as possible and liable to rot; hence the anxiety of cigar-makers to sell their cigars as early as possible." In a further note, he adds .—" There can be little doubt that cultivated tobacco land will largely increase when the railway runs through the Wanni and the limited market for local tobacco, as it is at present produced in Ceylon, will be flooded. Prices will drop till the industry will become unprofitable unless the Ceylon tobacco is rendered acceptable to other markets than would at present receive it." The Ceylon Government Administration Report for 1902, says:—" There has been a fall in the price of the leaves grown locally and it is a matter of great anxiety with the tobacco-growers of the Province that the price is on the decline for some years past. The fall in the price is chiefly owing to the markets being glutted and, unless a fresh market is found for the local product, no material improvement can be effected." A trial was made by Mr. MacDonald Gibson at Pallai in curing the Jaffna tobacco to suit European markets. He says:—" I have nothing new to mention regarding this important industry which will continue to be unsatisfactory to the producer until he begins to realize the necessity for improved methods of curing the product. I can only call attention to my observations in previous Administration Reports." In the *Jaffna Catholic Guardian* we find the following:—" Tobacco cultivation is extending in the Northern Province; but the general complaint of the tobacco traders is that the leaf produced is getting to be more and more deteriorated in quality. This is due to the want of high cultivation and high manuring, which are necessary for the production of a good article possessing the desired strength and flavour. The labour and manure bestowed formerly on one acre is now spread over two or three; hence the great inferiority complained of. Cultivators who look more to the quality than to the quantity of the crop, find to their advantage, that it raises competition among purchasers."

The same words might well apply to Indian-grown tobacco, especially now, when American cigarettes are imported into the country by the million and the taste of strong tobacco, formerly universal, is now slowly but certainly changing to that of the American cigarette and the cigar of indigenous tobacco wrapped in a Sumatra leaf. As in other parts of the world so also in India, smokers are becoming more exacting in their demands, are more fastidious, and constantly insist on obtaining better goods *for their money. The trade, however, always pays well* for good tobacco.

To raise a crop of tobacco is about the easiest thing, but it is quite a different matter to make a crop pay well. *Still, care and attention, with occasional experiments* on a small scale at first, will enable a farmer to produce tobacco better than that received from countries where it has been grown a hundred years.

The most careful attention must be paid not only to its curing but to the mechanical texture of the soil on which it is grown and to the use of complete and well-balanced fertilizers. The percentage of nitrogen is greater than in any other crop; part of it exists as nitrates, the ribs sometimes containing as much as 10 per cent. The composition of tobacco is very variable as seen from the analyses, and, like all green crops, its constituents are much influenced by the manures. Nessler has come to the same conclusion as Wagner that the quality of the tobacco is improved in proportion to the amount of potash salts in the soil (or added to it by manures) capable of producing potassium carbonate in the ash. The amount and composition of the manure required for any particular field is sometimes determined by an analysis of the soil, but nowadays the more practical Americans calculate what the plant removes from the soil by analyses of the crops and draw inferences from observation of the defective properties of the leaf. If, for instance, too much nicotine is observed though the land was otherwise suitable, it indicates that the manure given was too highly nitrogenous. If, as is so often the case in India, chlorides abound in the leaf, we may, with confidence, look to the faulty manuring or watering, both of which so frequently contain a high percentage of salt.

The bad burning and black ash of Indian tobacco point only too clearly the well-known deficiency of the soil and the manure in potash and the consequent absence of carbonate of potash in the leaf.

It is said that, owing to volcanic action in Java, there are spots where no artificial manuring is required; but, as a rule, even the best soils are, before long, depleted of their plant-food and unable to grow so exhausting a crop unless fertilizers are applied to return to the land the plant-foods extracted by the harvest.

In the Godavery and Kistna delta where the famous Lunka tobacco is grown, we have climate and soil the most favourable, on the sandy islands from which the rivers recede, leaving an alluvium silt, yet Mr. Caine, the tobacco expert engaged by the Madras Government to make a tour of inspection of the Godavery Lunkas, pronounced the cigars " execrable, being strong, rank, hot and saltish to the taste, besides gritty and full of sand," though he believed it could be made to compete with Virginian tobacco and bring from 8d. to 1s. per lb. in England.

How far this defectiveness is due to faulty manuring and how far to bad curing, has not yet been decided. Wherever good tobacco is grown in India it will be found that the peasant uses all the manure available and all the ashes he can get to fertilize his fields. Unfortunately he has not much idea of balancing his manures for tobacco or, perhaps, he knows what is to be used but cannot obtain what he wants, owing to the difficulty of procuring manure of any sort. In the North-West Provinces 200 maunds of the richest manure available is often used per acre. But whether this rich manure that is available is all nitrogenous does not seem to be a point too carefully considered. In the Punjab, ashes are invariably used where procurable, so that it appears pretty plain the rayat knows that potash is both useful and necessary for his tobacco. Just outside Bhilasa a small plot has been famous for its superior tobacco during the last 100 years ; but in this not only is horse, cow, and sheep dung used extensively, but a large quantity of ashes, with straw, is added, and the baked clay of earthen pots.

Unfortunately the mineral constituents or ash of most Indian tobaccos contains much less potash than the fine American tobaccos.

The Spaniards brought tobacco from Mexico to the Philippines shortly after they had conquered the islands, and the land is capable of producing as good leaf as the Vuolto Abaja District of Cuba. Though the choice Manilla cigars come from the Philippines, the tobacco is gradually becoming inferior, the result, no doubt, of a depletion of the soil and a neglect to replace in the fields the foods taken out by the plants.

It is not only in India that experimenters with exotics and users of new manures are laughed at. In the United States of America, the Department of Agriculture tried Sumatra tobaccos under shade in the Connecticut Valley. Of course the farmers around had grown tobacco for years. They knew what the soil and climate could produce and the sort of tobacco that could be grown in their district, and they were rather amused with the new fad of bringing in a new tobacco. But within a year, they learned that an exotic tobacco could be grown on their soil and fetch a price far above anything the ordinary kind had realised in their markets. I quote *in extenso* from the Report of the Director of the Connecticut experiments because I believe the introduction of exotic tobacco will prove highly beneficial to India, and there is no reason why experiments with these should not be tried while every effort is being made to improve the indigenous variety. I have tried American tobaccos on the farm of the Presidency Manure Works, Ltd., in the North Arcot District, with wonderful success, and the seeds from Sumatra gave results as good. The Connecticut Report runs as follows:—"The best Sumatra type is a leaf smaller than the Havana, 16 or 18 inches being the desirable length, light to medium colours, with open grain, free burn, great elasticity or life and very thin texture. That is what the trade wants. In 1900 the Connecticut Agricultural Station began trying to raise this quality of leaf. One-third of an acre was enclosed with a substantial wooden frame, to support a cover of very thin cheese cloth nine feet above the ground and closed on all sides to the ground with the same material. The soil was fertilized as usual for our other leaf and half the acre was set with Sumatra plants and the other half with new England Havana. Both were set much closer than is usual in rows of three feet and one-and-a-half feet apart and plants 12 inches apart in the row. The cover was a perfect protection against insect pests. Cut worms did some damage to the young plants, but no flying insects preyed on the tobacco. At harvest it was very hard to find a leaf which showed insect bites. The tobacco was also perfectly protected from wind whipping and from light hail. The temperature under the shade was considerably higher than outside and fluctuated less. The two rows each of Havana seed leaf and of Sumatra grown under the shade, were topped rather high. The leaf from the topped plants, however, after curing, was seen to be distinctly inferior to that of the untopped plants. The untopped tobacco of both varieties grew to the cover 9 feet from the ground and the Sumatra stalks bent over and grew to a length of 10 or 11 feet. The occasional rain and wind storms of the Summer did no serious damage to the cheese cloth. The leaves were picked or 'primed' when they were thought to be ripe, strung on strings, cured in the usual way and then fermented in a pile or 'bulk.' When ready for market, samples were taken from the several primings except the first, which included only inferior bottom or sand leaves. Each hand was a single string of leaves just as the girls had strung them and therfore represented the general run of the leaves and not a selection. After taking samples, this little broken lot of Sumatra leaf, from only one-sixth of an acre, sold for 3s. per lb. The samples were sent to a number of leading dealers and manufacturers with the request to examine carefully and give their opinion of the quality of the leaf and to state fully its defects. These reports, from men who are in touch with the present condition and requirements of the tobacco trade, and who had no personal interest in the crop, settle, beyond dispute, the quality of the Sumatra tobacco we raised."

Rupees 2 annas 4 per lb.! Only to think of such prices alongside a Government report concerning the price of Indian tobacco, which reads :—"A well grown crop is expected to yield from 20 to 24 maunds per acre (80 lbs. make a maund), the money value of which may be estimated at Rs. 100 to Rs. 120, Rs. 5 being the average price per maund of country-cured tobacco." A penny a pound! An objection may be raised that the Connceticut leaf which pays so well and the still better results obtained from the Sumatra tobacco were probably due to the soil and climate, but the State is on the borders of the Atlantic, has a poor soil, and is subject to great cold, facts which show that most places in India are better suited for the production of a really excellent leaf.

In order to obtain the same combination of strength and aroma as the acclimatized plant, it must be placed under equally favourable conditions of temperature and moisture. In this respect India is situated more favourably than the European States, where foreign varieties of tobacco have been acclimatized. In Europe, the climate is such as not to allow of the full attainment of the original aroma, but Cuban seed has been successfully grown in Austria with a remarkably good aroma, and there is no reason why foreign seed should not be grown and the tobacco retain its original qualities, if manuring and curing are properly attended to; for, in this vast country, a soil and climate should not be difficult to find, suitable for thoroughly acclimatizing the plant. The present stock is foreign to India, and, as ground nuts and other crops become in course of time indigenous, we ought soon to have an excellent tobacco on foreign markets, and India should be the chief tobacco supplier to the rest of the world.

The mere chemical analysis of a soil helps us very little in determining the nature of manures to be employed, so much depends on climatic conditions and the texture, if I may use such an expression, of the soil. One tobacco analysis is very much like another, but, a slight variation may make all the differenece between good and bad Tobacco, as, in essences, the change of one atom of hydrogen may make the difference between a scent and a stench.

The soil, however, by careful attention, can be rendered as nearly as possible similar to that of the finest tobacco-growing districts, and then fertilizers, the cutting, sorting and curing, must do the rest. In sandy soil the best tobacco is grown.

	Sand.	Silt.	Clay.
New York soils show...	68·81	18·18	7·43
Massachusetts	60·10	33·60	3·31

It is interesting to note that the coarser or filling tobaccos of cheroots and cigars are from soils composed as follows :—

	Sand.	Silt.	Clay.
Pennsylvania ...	17·27	49·02	29·27
Ohio	23·31	44·31	27·52

A. M. Howell in the *Australasian*, whose knowledge was acquired in the Southern States of America and improved by the growing and curing of tobacco on modern scientific principles, states that the main questions, involved in the production of a good crop of tobacco, are :—

1. The selection of suitable soil for the type of tobacco desired to be produced.

2. The selction of a suitable variety or varieties of tobacco, looking likewise to the class and type desired.

3. The cultivation of the crop, including the work of the hoe and plough, the prompt and diligent pruning of the plants, the extermination of insect pests and all else that can be done to promote the fullest expansion of the leaf.

4. Preparations for curing and harvesting the crop at the proper stage of ripeness, looking to a uniform yield of ripe, mature leaf, and to desirable colours.

5. The curing process—the *ultima thule* of the tobacco grower—how to produce bright and beautiful colours that at once captivate the tobacco manufacturers and command the highest market prices and pay the producer a good round profit.

6. The care of the leaf after it is cured, which means its preservation in sound condition and the fixing of the colour, which may be lost or faded or deepened into other shades by improper management.

7. Packing and marketing—in the iocal home market or abroad—with extreme care as to contents of moisture and the possibility of dangerous absorption of moisture in the hold of the ship.

Of these the fisrt is the most important point to be considered. Notwithstanding the most skilful curing, which can make the best that is possible of any leaf, the influence of the soil must always tell.

For growing cigarette tobacco and very fine wrappers a dark rich soil would prove hopeless. In Grenville County, North Carolina, where the finest types of bright tobaccos are grown, the soil is so sandy and poor that the farmers there say that it will hardly "sprout cow-peas." Fine deep sand, with a friable workable soil that maintains a proper percentage of moisture, enables the leaf to expand to its utmost. The ribs and veins of a tobacco leaf never increase in number : whether the leaf be half an inch or three feet in size, these remain the same, and consequently, the greater expansion of leaf, the greater the proportion of ribless and veinless matter and the greater the number of cigar wrappers obtainable between the ribs.

Of course, such lands as these described above require heavy manuring. Farm-yard manure is sparingly employed, but special mixtures of commercial fertilizers are added, so balanced, that the requisite amount of mineral matter, viz., phosphoric acid and potash are supplied. Here the analysis of the plant helps us to a great extent, and experience must come to our aid when practice shows that more of a plant-food is required than the analysis seems to justify. The essentials requisite in the manufacture of high grade cigars are :—The tobacco should burn pleasantly with a pleasant taste, not rank and strong, nor too mild, and the aroma will be good. The wrapper should be also light in colour, rich in grain, thin in texture, small in vein and stem, elastic, and of good burning quality. The leaves should be as unifrom as possible in size, colour and quality. A leaf between 15 and 17 inches will produce four wrappers, and is consequently a size that producse least waste.

The Sumatra tobacco-growers give the most careful attention to these points and they get a big price for their trouble. The Americans know that quantity alone does not pay and so they look most carefully to the quality of the leaf they can produce. They evidently understand the full value of the trite old saying : "If a thing is worth doing at all, it is worth doing well." Notwithstanding the cost of shading and labour on farms in the United States the people have not been deterred from making the culture of Sumatra tobacco a decided success. Natives of India will scarcely credit the fact that tobacco can be grown at a profit under a cheese cloth shelter that cost no less than Rs. 1,050 for one acre. But the price obtained for the produce will explain this. It is certainly not leaf at Rs. 5 per maund that would repay such expenditure. With everything so much cheaper in India it ought to pay to grow the best tobaccos. It is not sufficient to have a good wrapper to make a good cigar. The all-important part is the filler and to grow this a different soil is required. which should contain more clay and silt and less sand. Shorter leaves of a rich brown colour burning freely and having a good aroma are used as fillers, and excellent tobaccos of this description are grown in Northern Luzon (Philipines) and in Pennsylvania, Ohio and Wisconsin in the U. S. A. Some excellent filler tobacco is also obtained in Southern India especially in and around the Trichinopoly District.

Dark rich soils produce a large crop of heavy coarse leaf with large ribs and veins, which burns badly unless its manufacture is thoroughly known. When made into cigars it is strong, biting, and evil smelling. The flavour and aroma are both poor. It is used for pipesmoking. Though the quantity is great per acre the price is so low that it does not pay well. The choice of the soil is all—important in the culture of tobacco, though, given a fair chance, a farmer can fit his fields for any tobacco in course of time. But, as in all farming, the question arises whether it would pay, whether the game would be worth the candle, and whether it would not be more advisable to select in the beginning, a soil suitable to the tobacco you wish to grow, using commercial fertilizers to supply the necessary plant-foods. In the United States, as great a success has been made with pine-apples as with tobacco, on soils that apparently were worthless, because the farmer there, satisfied that the texture of the soil was fittest for his crop, knew that he could supply the plant-foods required to obtain the best paying harvest. Whatever the nature of the soil, too great a proximity to the sea must be avoided, for all experts agree that tobacco grown too near the sea burns badly, and if it contains 3% chloride it does not burn at all.

An application to the officials of the Indian Agricultural Department for seeds of the finest quality of tobacco will be attended to at once, and, as experiments with foreign varieties have already proved successful on demonstration farms in this country, it is probable that intelligent farmers will make similar trials. It will be the same cost to grow the best as the worst tobacco in the open, but the difference in the price of the harvest will be very great and amply repay them for any extra care that may be taken.

As to cultivation there is no need to give advice to the raiyat. There are few farmers in the world who can teach him anything in this respect.

He has, however, confined himself, till now, to raise the ordinary coarse tobacco smoked in the country and has consequently not given to the harvesting that care and attention required by better qualities that pay so well in foreign countries and in the rapidly growing markets of India.

Many authorities believe far more satisfactory results are obtained when the leaves are 'primed' than when the entire stalk is cut. In 'priming' the leaves are taken off the stalk as they ripen and this prevents the carrying of much green tobacco to the shed. Tobacco should never be cut or primed when wet with rain or dew, as this causes the leaves to sunburn and little holes to form, which lowers the value of the leaf.

Clarence W. Dorsey, an authority on American, Manilla, and Sumatra tobacco, says :—

"If the tobacco gives promise of being 'wrapper'—that is, if it is light green, very sound in leaf and of desirable size—it should be primed at an early stage of ripening. If, however, appearances indicate that it will prove 'filler' tobacco, it should be allowed to thoroughly ripen. Early or low topping is not desirable, as it throws too much growth into the leaves, making them too coarse and large. If the plants are thrifty and the weather favourable for growth, it is frequently advisable, if thin, fine-textured leaves are desired, not to top the plants at all, but let them produce their flowers and seed pods. If, however, the plants seem weak and it appears that they cannot mature the full number of leaves, they should be topped by pinching out the 'buttons,' allowing as many leaves to remain as the plant will be able to mature. When plants have been topped too low and the leaves thicken and curl, a few suckers may be permitted to grow, which will remedy any thickening or curling. By using good judgment in the matter of topping and suckering, and making proper allowance as to the soil and climatic conditions, the leaves can be grown to almost any thickness that is desired." In Northern Luzon, the gathering of the ripened leaves is spread over 40 days, five gatherings taking place, one after every 8 days. The primings should be kept separately in the shed, and fermented separately, for the leaves from different parts of the plants require separate treatment. Throughout the growth of the plants constant care should be taken against insect pests of all kinds. Worms should be removed by hand or the whole crop sprinkled with insecticides such as Paris green. For seeding, only the best plants should be selected and allowed to grow to their full height.

Though priming may be somewhat more expensive it certainly pays best with choice tobaccos.

As the value of the tobacco depends so much on the manner of curing, great pains should be taken about the fermentation and subsequent sorting and grading.

Fermentation brings out the proper texture, glossy appearance and colour of the leaf, and the characteristic properties which are scarcely apparent when the leaf is cut in the field.'

As to the art of "curing tobacco" it is not to be taught by books. One, expert in the business, must teach it; but experience will soon be gained by the raiyat, and, once a determination to improve the indigenous leaf and to profit by the culture of the best exotics is made plain to the Government, I have no doubt the authorities, in their own interests, as well as those of the farmers, will push the industry with as much anxiety as ever was shown in the improvement of the cottons of the country, though it is to be hoped that interference with the raiyat's method of agriculture will be avoided, for mistakes enough and heavy loss have always been the result of an attempt to improve on the Indian peasants' method of tillage. Experts can then be brought into the country from Cuba, the United States, Sumatra and Manilla, to teach the Indian farmer to make the most of his improved crop. When that day arrives, tobacco-growing will be a source of great wealth to the country. There is an immense field in India for the culture of tobacco, and a still greater one for the improved preparation of the leaf. It would pay well to give the greatest attention to manures and fertilizers, especially to the use of potash, which is acknowledged to be badly wanting in the tobacco crops hitherto raised in the country.

TEA.

A FEW HINTS ON MANURING.

The three great growing centres of tea are China, India, and Ceylon. Indian tea goes half as far again as China tea so far as depth of colour and fulness (not delicacy) are concerned, one lb. of China tea producing 5 gallons of tea of a certain depth of colour and fulness of flavour, whilst 1 lb. of Indian tea will produce 7½ gallons of a similar beverage. China sent in 1865 to the United Kingdom 98% of the tea imported there, whilst India was responsible for 2% and Ceylon sent nothing.

	China.	India.	Ceylon.
In 1875 the figures had changed to	86	13	0
In 1885	66	30	2
In 1895	16	46	32
In 1899	12	50	35

showing that China tea has been pushed out of the United Kingdom in favour of Indian and Ceylon teas. It was in the middle of the seventies that a disease "Hemeleia Vastatrix" wiped coffee out of Ceylon and ravaged the estates on the adjoining continent. The predisposing cause has never been ascertained; but I am inclined to believe, and I have the opinion of old coffee planters on my side, that the burial of pulp at the roots of the plant had a great deal to do with the total destruction of the coffee in Ceylon, and the application of the same in a half-rotted condition on Indian estates caused the terrible devastation then experienced, though the evil was not so great, as pitting had been in vogue here, whilst burial in the rows was the practice in Ceylon. My reason will be given when dealing, later on, with the burial of prunings

As nothing remains on the soil to replace the plant-foods taken away in the leaves, there must come a time, when tea soils suffer depletion unless manured, and the fertilizing, to produce good results, must be complete, sufficient and well-balanced. To judge from the best authorities in India and Ceylon this period has been reached. The *Indian Planters' Gazette* of April 19, 1901 contains an article on the "Renovation of Tea" Estates, by an Old Planter, from which the following extracts are taken :—

"The lighter soil in Sylhet and Cachar is exhausted, and though persistence in keeping up estates which yield but meagre returns (that cannot really be considered legitimate profits) may suit the views of certain interested parties, who alone benefit, the hopes of shareholders grow fainter every successive season. The chief need of the tea plant is ammonia, which, by enriching the sap, gives greater strength to the leaf, which, sales show, the Surma Valley teas are deficient in ; phosphates develope wood and fruit, corresponding to bone and muscle, but as the ordinary run of our plants are tolerably supplied in this respect when not knotted and gnarled by the now fortunately obsolete system of pruning ; the bonemeal vended does not contain a sufficient proportion of ammonia to bring our leaf up to the mark ; an undue amount of the alkali would prove detrimental, but 25 % is certainly required, so that agents might well put themselves into communication with the local gas works upon the subject.

Mr. Mann's whole attention should be directed to the subject of manure ; we do not require analysis of soils, which everyone knows have long since parted with whatever productive properties they may have at the outset possessed. Few, even if they have the land, can afford the expense of extensions, which will return nothing for four years, and a good number, by ill-advised relinquishments, have brought their whole available area under one plant. The only hope therefore lies in renovation ; the alternative we need not dwell upon. Rule of thumb planting must give way to systematic gardening, which ultra-conservative orchard owners have at length realized in England."

At a Meeting of the Indian Tea Association in Calcutta in 1902, Dr. Mann, the scientific expert, said :—

" The Chairman has asked me to say something about the tour recently made by me in the tea districts in the course of which I visited almost every district in Assam. There was nothing which struck me more during that tour than the fact that during the past few years there has been a continual expansion of tea, and really without any effort or very little being made to keep up the production of area already under tea ; in fact one or two gardens which I saw gave figures which seem to show that, with the area doubled, the product of tea was precisely the same as it was before. I cannot help the conviction that the whole of that decreased reduction per acre under tea cannot be explained by any method of finer plucking. What we need is a concentration of attention to the area already under tea. To say the least, it is a bad thing to go on extending the tea area without giving time, attention or money to keeping up the production of the area already under tea. At the present moment it does not seem to be the idea of the Committee or of the tea industry to increase production at all.

The idea is more that we should devote our attention to the improving of the quality, or rather keeping up the quality we have already attained to. There seems to be no doubt that during the past ten years the quality of the tea from a very large number of the Assam tea gardens has deteriorated; that is more especially the case in those districts which have up to the present been famed for a high quality of tea. I am at present devoting more attention to this point than to any other. My investigations at present are directed to finding what constituents in the soil render it capable of producing high quality tea and what constituents are present in those gardens which are, or have been, famed for the quality of the tea they have produced."

The amount of British capital invested in tea gardens is about £30,000,000. In Ceylon, which in 1883, sent 1,000,000 lbs. of tea to London and increased that to 115,000,000 in 1900, there is no doubt that manuring plays an important role, but there is danger that in trying to avoid expense, serious harm may be done. Mr. Joseph Fraser, Chairman of the Directors of the Pitakande Tea Company of Ceylon, Limited, and an authority on tea-planting, unfortunately recommends the burying of prunings and, notwithstanding the opposition of many scientists, not only maintains that it does no harm, but attempts to prove that it is beneficial. One of the laws of sanitation in human life is the removal of all excreta from the surroundings. Emanations from the body are pleasant when slight, and will explain the love of the old arm chair, old garments, the old house, etc., and why some people cannot sleep well in a new bed. These emanations, when over-concentrated, become noxious and poisonous. We shall probably find the same rule as an axiom of plant-life. Nothing else can explain the inability of beet to grow on soils on which it has been raised continually for some years, though the mere burning of the soil renders the land again fit. This alone will explain clover sickness and the apparent mystery of orchards suffering, if over-run with grass, and will probably account for the dying down of whole forests in course of time and these being succeeded by trees of quite a different species. Mr. Joseph Fraser refers to the Pitakande Estate to prove that the burial of prunings is not only harmless but positively beneficial, taking as it does the place of manuring; but in the *Tropical Agriculturist*, in reply to this statement, I find a letter from Mr. F. L. Clements analysing the experiments carried on for six years on this Estate. His remarks are suggestive, and not in favour of the burying of prunings—in fact he produces the evidence from Pitakande to condemn the custom. He says:—"Unfortunately I have not seen the list of experiments but presume that pruning was carried on in the 2nd, 4th and 6th years. If such be the case, I presume that the burying of prunings took place in the same years and there is nothing more damnatory of burying than the results shown there."

The fall in the average product would certainly not have been so great, if no manure had been used. The burying of prunings appears to me to be the cause and with Mr. Clements I am inclined to ask:—

"Do these figures also indicate a steady deterioration of the tea bush and of the soil" and to add:—"Does not the cause lie in the placing at the plant roots the very excreta of the plant itself"? At the risk of being too prolix on the subject I give the opinion of

Mr. John Hughes, Agricultural Analyst, that appeared in the *Tropical Agriculturalist* :—

"Judging from notices in the *Ceylon Observer*, it would appear that practical tea planters are becoming doubtful of the general utility of burying tea prunings in trenches under all conditions of soil and weather. At an important meeting at Dimbula, it was stated that prunings which had been buried just previous to a very wet season in the Uva District, had not decomposed at the end of three or four months of very wet weather; but that an injurious fungus was developed to such an extent that one per cent of the tea bushes had died in consequence. The idea of utilising the leaves and small twigs of tea prunings as a future source of humus to the soil, is no doubt correct in theory, but to be practically useful the conditions of the soil and weather must be favourable.

Green leaves, like green grass or clover, buried near the surface in a light porous soil, followed by a period of hot dry weather, will rapidly decay and afford valuable plant-food. But damp green leaves associated with large branches buried over six inches deep in a stiff ferruginous clay soil, saturated with water, are more likely to be a serious source of danger than a source of plant-food to the tea shrub. In the presence of an excess of moisture and a deficiency of air, an acid decomposition of the green leaves is likely to be set up, and the resulting acid compounds will not be conducive to the healthy growth of the rootlets of the shrub. As long since as 1863, the late Dr. Agustus Voelcker, F. R. S., writing in the journal of the Royal Agricultural Society on " Manures for root crops," stated that :—" No acid combination, as such, can enter into plants without doing them serious damage ; even free vegetable acids such as Ulmic and Humic acid are injurious to all crops cultivated for food for the use of man or beast ; and unless these acids, which are always present in what practical men call sour humus, are neutralized by lime or marl or earth, none but the roughest and most innutritious herbage can be grown."

The above was the opinion of one who was rightly regarded as an authority on the properties and application of artificial manures.

The success, which has attended the use of non-acid manures such as Basic Slag and the more rapidly available manure, known as Basic Superphosphate, is largely due to the fact that both these fertilizers have a distinctly alkaline reaction and are specially suitable to soils deficient in lime like those of Ceylon tea estates. The addition of Basic Slag, however, to the buried prunings cannot be done sufficiently to ensure the complete neutralization of the acid decomposition. Consequently, instead of burying the prunings the safer plan, in the writer's opinion, would be to remove them, and after stripping off the leaves at some central spot, to stack the branches for future use as fuel and to allow the leaves to decompose in a heap, sprinkled with some soil and a little freshly burned lime. If the object is to convert the leaves into healthy and useful humus, the process of decay will certainly be carried on much more rapidly when the action of the air is allowed to have full effect, rather than when the leaves are buried in trenches, in a stiff clay soil, sodden with excess of accumulated water.

The Pussewala Planters' Association to collect statistics as to the existence, spread and best means to combat pests and blights affecting tea in this District, are, from quite another point of view, opposed to burying of prunings, as they record :—

"The conclusion this Committee has inevitably arrived at with regard to the shot-hole borer is, that it is the the most serious pest that has yet been known to attack tea over any extended acreage. The affected area has, undoubtedly, largely and rapidly increased during the last few years, and drastic and systematic measures are absolutely necessary to keep it in any sort of check. Weighing the evidence afforded by responses to their circular this Committee considers that the present inroad of the borer necessitates the destruction of all prunings over affected areas, and would go so far as to recommend legislation to make this compulsory."

Mr. Green, the Government Entomologist, in the course of his address on the subject to the members of the Association, said :—

"From what I have seen of shot-borer (I have known it for over 13 or 14 years) it began in Nawalapitiya district and was noted in one of my first reports. I have not heard of a very large dying out of tea due to it, and I have never got reliable reports of the death of a single tree which could really be put down to shot-borer itself. But at the same time I should like to point out that to keep it in check I consider the destruction of prunings is one of the important points—not the only important point, because I think there are several things which ought to be attended to."

A number of diseases are prevalent on tea plantations and in every case the advice is to cultivate well as a remedy against these diseases.

The appearance of various enemies to plant-life as the tree begins to sicken are put down to causes when they are mere accompaniments, often the most telling signs that the estates want better culture.

Reporting on a tea Eelworm disease in Southern India, Mr. C. A. Barber, Government Botanist, Madras, after stating that it might spell disaster if the pest once got a fair hold of a perennial like tea, remarked that "it was frequently the result of carelessness or insufficient cultivation, especially on old garden lands which had been allowed to run to waste."

A well-manured, well-cultivated estate can hold its own against all enemies and soon recover if attacked. Mr. Green of Ceylon has impressed this upon planters in the following words:—

"I think there is no doubt that it will necessitate more liberal cultivation than has been the custom in a good many places if tea is going to be kept up to its present standard of bearing. But beyond that I think if you keep the prunings destroyed and prune at fairly frequent intervals and keep the tea in fairly good heart, it will be able to fight its own battles. I have frequently found, in vigorous tea, that the tendency of the plant is to deposit fresh wood over the hole made by the borer and you will often find that the entrance hole or exit hole—it is all the same—has been blocked."

Tea estates are often kept scrupulously clear of weeds. Whether this is wise with fields which have no rotation crops it is not so easy to determine, though I am inclined to believe that weeds would be useful, not merely to prevent the washing away of the soil on the mountain slopes, but also to remove from the fields the effluvia from the roots of the tea plant that would other-wise become over-concentrated in the soil. The same purpose is probably served by the grasses and bushes in forests.

A coffee planter of the forties writing from Dublin on September 24th, 1899 (*vide* "Tropical Agriculturist," November 1900) says :—I must bear record to the only practical planter I ever met in Ceylon (George Crosbie). After he had planted "Bowhill" near Nawalapittiya, he never allowed hoe or scraper to be used by any of the weeding gangs: instant dismissal was the punishment for any infringement. The consequence of this wise rule was a growth of moss all over the planted portion and, in seasons when short-handed, he had the berries picked from under the trees and cleaned at his store, such coffee realizing 5*s*. per cwt. more than parchment at Colombo. After his death new-fangled ideas were introduced, hoe and scraper came into requisition and soon the soil which "G. C." tried to secure for the nourishment of the coffee tree was running off as peasoup to enrich low lying paddyfields; the tree roots were exposed and gradual decay set in. For ten years the average of Bowhill was 10 cwt. 1 qr. 15 lbs, per acre. After the new change it dropped off to 9 cwt. 7 qrs. and 5 lbs. and then 3 cwt. per acre, and eventually like all other estates similarly treated, became worthless. Poverty brought disease, which, like any other plague, extends and lays hold of good and bad. In this case, however, there was no remedy, for coffee is a surface feeder and the soil which should be strictly conserved was wasted. The soil on Ceylon hills is light, and never can be replaced by artificial manure, and to keep cattle is unproductive, as I know by experience. I never saw a cooly drop his manure beside a tree that had to be holed to receive it, but I said—there goes 3*s*. If this be advisable with a surface feeder like coffee, it ought certainly to have force with reference to tea and one is not therefore surprised when a Java tea planter wonders whether the ultra-cleanliness from weeds that every Ceylon planter thinks a *sine qua non* of good tea cultivation has anything to do with the increase in both the quality and quantity of disease which tea in Ceylon seems more subject to than in Java. He believed tea to grow stronger among weeds if bad grasses were forked out and the fertilizing weeds not allowed to grow too luxuriantly and then dug in. He stated that the only estate in Java on which he had seen grey blight belonged to a Ceylon man resident in Java on whose estate not a single weed could be seen.

Owing to the heavy cost in nitrogenous manures Mr. Herbert Wright suggested to the Ceylon planters the use of green manures giving the most roseate hue as to the results expected. There are three points, however, which require careful consideration before green manuring is resorted to, in order to avoid a possible danger of extreme harm being done to the bush :—

1. How long will it take for the nitrogen collected by the leguminosæ to be at the disposal of the tea bushes after digging in, and to what extent will the bushes, in the meantime, suffer from a want of nitrogenous fertilization ?

2. How much harm will be done to the tea bushes by the withdrawal from the soil of the available phosphoric acid and potash necessary to enable the leguminosæ to gather the nitrogen of the atmosphere?

3. And, perhaps, the most important question, will the tea plant thrive in the neighbourhood of such green manures as the ground-nut ?

Festina lente ought to be the planter's motto. Let him first try his experiments whether with ground-nut, crotolaria or any other leguminosæ, on a small scale, for a number of years, before resorting to any wholesale changes that may possibly bring upon his field a devastation as wholesale as that to which coffee was subjected.

For tea-sick soils there is no doubt the growing of a shrub or grass, that would feed upon the excreta of the tea plant, would be a remedy together with manuring, but æration and perhaps deodorising with charcoal will be found the only remedies, as rotation is impossible on tea estates. The experiment would not entail much expense and would probably repay the cost and trouble many times over in the first year.

What manures are most suitable to tea is a question long discussed by a number of practical planters anxious to make the most of their gardens—men, who move with the foremost agriculturalists of the day. In all their discussions in India, however, they seem to watch results obtained by single manures or chemical combinations that are not complete fertilizers, as they do not supply all the principal ingredients of plant-food. Another great difficulty with tea is the question of not merely large supplies in response to fertilizers, but the more important one of flavour which settles price. Experienced planters when speaking of different manures give almost diametrically opposite opinions as to the results of their experience. If ever a chemically correct combination of manures can be spoiled by the absence of one scarcely thought of little item, it is to be found in the case of tea. As excellent food can be ruined for the want of a pinch of salt, so manures otherwise complete are rendered far from perfect in their results by some apparently trifling omission. The analysis of the tea plant alone will not help us here, for the aroma cannot be easily analysed, though the latest researches regarding the tea enzyme put us on the road to discover the substance whose trifling omission in manures makes all the difference between good tea and rubbish. According to Dr. Wolff's tables, in 1,000 parts of the fresh air-dried substance, the tea leaf contains (medium quantity)—

Water	80·0
Nitrogen	35·6
Ashes	47·6
Potash	16·4
Soda	4·9
Lime	7·1
Magnesia	2·4
Phosphoric Acid	7·2
Sulphuric Acid	3·4
Silicic Acid	2·4
Chlorides	0·9

It is strange that iron figures so little in the leaf and so much in the soil of the plantations. Throughout Ceylon there seems to be almost a regular rise in the price of the tea according to the increase in the amount of iron in the estate. Another peculiarity about tea is that lime and phosphoric acid which seem required, to such an extent, by the plant, are seldom found naturally in any degree in the spots chosen for planting. There is a most interesting article by Dr. Harold H. Mann, D. Sc, then Scientific Officer of the India Tea Association, (now Principal of the Agricultural College, Poona) on "The ferment of the tea leaf and its relation to quality in tea." An extract from this will show the value of phosphoric acid in flavouring the best leaves, a material little found in many of the soils where tea is grown and yet a manure that can easily be supplied by bonemeal.

The *Tropical Agriculturist* of March 1902 describes a plant enzyme as "a substance existing in the sap, and which is capable of inducing chemical changes necessary to the life of the plant. As an instance we may quote the commonest of plant enzymes, known as diastase, which has the power to convert the reserve starch into a soluble sugar, which can be conveyed to the growing parts of the plant. In the leaves of tea, up to the present, no starch has been found, so that the action of the tea enzyme *in the leaf* is of a nature different from the above. Nevertheless, its function, that of rendering insoluble bodies into a soluble form, is probably similar to other enzymes.

In one or two instances the action of an enzyme has been utilized commercially to induce chemical changes, which result in the production of a more or less distinctive flavour. As an instance we may take yeast, a common plant, from which no less than five enzymes have been extracted. It has been found that different yeast cells impart to a fluid a different odour and flavour, and this has been used on the continent in the improvement of certain wines. It was shown, that if different portions of the same grape juice were fermented with different species of yeast, wines were obtained which differed much in flavour, because each species of yeast has the power of producing, during fermentation, certain characteristic flavouring bodies. As has been previously pointed out, however, we must remember that all such fermentations require a great deal of time for completion and they are therefore not strictly comparable with the changes occurring with the manufacture of tea. It would be unwise to jump to the conclusion that the enzyme in tea is responsible for what we at the present time know as flavour, although it is possible, that under certain conditions the enzyme will be found to materially affect the quality, and perhaps, to some extent, the flavour.

From Dr. Mann's valuable work on the subject the following is extracted :—

" *Distributian of ferment in the flushing shoot.*"—If the various leaves on a flushing shoot be taken, the amount of enzyme is by no means the same in every part. The fresh leaf for instance contains about an equal amount in the unopened tip leaf and in the stalk, but below the tip the percentage decreases in every leaf. Taking the leaf as plucked for instance on a China hybrid bush in September, the following table gives the relative amount present in each leaf separately, calculated both on the fresh leaf and on the dry matter in the leaves (taking that in the tip leaf as unity) .—

		ACTIVE	ENZYME
		On fresh leaf.	On dry leaf
Unopened tip leaf	...	1·00	1·00
First open leaf	...	·64	·65
Second open leaf	...	·48	·48
Stalk	...	1·13	1·64

These figures apparently seem to indicate that where the largest quantity of enzyme is present, the best tea is made, and yet not wholly so, because the stalk which is objectionable in the tea, contains as much as any part. The reason of this is seen, however, if the relative amount of acidity, of tannin, and of phosphoric acid in the same samples of these leaves are taken.

These give the following figures:—

	ACIDITY Fresh leaf.	Dry leaf.	TANNIN Fresh leaf.	Dry leaf.	PHOS. ACID. Fresh.	Dry.
Unopened tip leaf	1·00	1·00	1·00	1·00	1·00	1·00
First open leaf	·94	·94	1·03	1·03	·88	·88
Second open leaf	·94	·94	·91	91	·75	·75
Stalk	·47	·70	·59	·86	55	·79

It therefore appears that, where a large amount of enzyme is combined with the greatest acidity, and with the greatest amount of tannin, there the tea produced is the best. Such is only a preliminary conclusion, and it must be considered strictly applicable to similar conditions. It is however one to which the next set of experiments gives support.

Relation of ferment to quality.—Several gardens were taken in the Darjeeling districts. "A" produced average or rather better than average Darjeeling tea; "B" has for many years produced absolutely the best tea in India; "C" is giving, during the present season, the highest priced product in the district. Conditions being therefore as near as possible equal, the quality, if the above condition be true, should vary according to the amount of enzyme present, provided the same amount of stalk or approximately so, be present in the samples. Comparing first, garden "B" with garden "A' "B" No. 1 is from a young Assam or high hybrid extension giving very fine tea. "B" No. 2 is from a low Assam extension giving the worst tea on the garden, but yet an above-average quality. "B" No. 3 is from China tea, giving an excellently flavoured product. Determining the enzyme present in each of the samples in September

1900, and comparing the amount with that in "A" (China hybrid plant) we have, taking "A" as unity :—

		Active Enzyme
A	...	1·00
B No. 1	...	1·88
B No. 2	...	1·17
B No. 3	...	1·83

In this case the active enzyme seems therefore to be a fair measure of the quality producing character of the leaf. The same result is shown on garden "C" as follows :—

		Active Enzyme
A	...	1·00
C No. 1	...	2·17
C No. 2	...	1·44

Here C No. 1 represents the very highest quality Assam bushes and C No. 2 similarly the best China plants in the garden. In C No. 1, probably a little larger stalk occurred, but A and C No. 2 are absolutely comparable and here it will again be seen that flavour in the tea follows the enzyme in the leaf. Hence one may, I think, conclude that other things being equal, the flavour in the product is materially connected with the quantity of oxidase in the leaf from which it is made. This conclusion as stated above, will have to be supported by many more experiments before one can consider it satisfactorily established, but in the meantime there is strong and consistent evidence of its substantial accuracy.

How then can the oxidase be increased in the leaf? In a table on page 8 it was shown that, taking the various leaves on the same stalk, the amount of phosphoric acid varied very closely with the amount of oxidase. In addition to this I (Dr. Mann) have in a previous report

(Tea soils of Assam and Tea manuring, November 1901) brought forward very strong evidence that the quality of tea is materially influenced, at any rate in Assam, by the amount of phosphoric acid, and especially of available phosphoric acid in the soil. Now not only is phosphoric acid present in greater quantity in the leaves on the same stalk which gives the same enzyme and produces the best tea, but also there appears to be most of the constituent in the soil of those gardens giving leaf containing the most oxidase and making the best tea. The following figures for the soil of the gardens A and C where the leaf mentioned above was obtained, show this very clearly.

Percentage in the soil A. ·061 ; C. ·124.

The conclusion drawn in my previous report above-mentioned that, in order to obtain high quality of tea, there must in any case be a large quantity of phosphoric acid present in the soil, is here confirmed, and this phosphoric acid becomes, in addition, apparently connected with the quantity of enzyme in the tea leaf."

From the analysis we see the need of potash, and from Dr. Mann's learned and interesting paper, the value of phosphoric acid, and we should recommend these as additions to any other manures used.

Though it would be advisable to know something of the land to which a manure should be applied, a fairly good idea of the requirements of tea estates can be gathered from the interesting experiments and their results, to be learned from a paper of Mr. W.D. Bosanquet read by the Chairman, Dimbala Planters' Association, at a General Meeting.

He had had many years of experience with coffee till green bug wiped that off the land, and since then made careful experiments of the effect of manures on quantity and quality alike. He says:—"With the coffee it was comparatively a simple matter as the object was solely to find out how to produce the largest crop with the least injury to the tree, whereas with tea it is at least as important to find out how far the quality is effected by the manure. On this latter point I have only been able to draw my conclusions from my general experience. Many seem to think that all manures should be suppressed by legislation, as tending to over-production, which is not only impracticable but shows how little the true principles of manuring have been grasped. I believe it is quite possible to manure in such a way as to keep the tea at a normal level of production combined with a good quality and that it will pay better in the long run to work on this system. Such at any rate are the conclusions I have arrived at after ten years of experience of manuring tea and eight years of experiment. My first experiments were conducted with the object of finding out the most important element required in a manure for tea and were so carried out as to compare the results of adjoining plots of one-sixth of an acre by leaving out one element in each plot on the plan of Mr. Villa. The most important elements removed by the tea crop are in 1,000 lbs. of tea:—

Nitrogen	45 lbs.
Phosphoric Acid	8 ,,
Potash	22 ,,

I was very soon convinced that the dominating element was nitrogen—that is to say, without nitrogen, phosphoric acid and potash were almost inert. That for the best effect, all three elements were required, and more especially potash. That additional nitrogen meant an increased yield but did not invariably pay, owing to the great cost of nitrogen.

The great cost involved has prevented my experimenting in the direction of finding out the effect of different manures on quality, and I have to fall back upon general conclusions from the observations on manuring on estates under my own direction and that of others.

Nitrogenous Manures.—As regards their effect on quality I give the preference to castor cake. Blood meal alone is too forcing and quickly used up. Sulphate of ammonia has invariably appeared to me to be accompanied by a loss of quality, whether used by itself or in combination, though it may be only a coincidence.

Fish manure I have used only once, and I confess I have a dislike to it as being too stimulating in its effects, and its use has seemed to me usually accompanied with a loss in quality.

Nitrate of Potash.—I think useful as a source of nitrogen and potash—the nitrogen coming into action very quickly but being speedily washed out in wet weather.

Phosphoric Acid.—Basic Slag I look upon as a very valuable source of phosphoric acid and I am inclined to endorse Messrs. Freudenberg & Co.'s statement that it tends to maintain quality in tea owing to the two oxides of iron it contains.

Bones.—Either steamed or ground should, I think, form part of every manure mixture, as the phosphoric acid contained in them comes into action gradually and is not too speedily used up.

Potash.—I give the preference to sulphate of potash as the source of potash, as being retained in the soil better than the nitrate. Potash I consider is a most important constituent in a manure if quality is to be maintained. Potash is known to have great effect upon the carbohydrates of plants, that is to say, upon their main structure and ever since the time I commenced my coffee experiments I have noticed that potash improved the health of the trees to which it was applied. I believe it is of great value in helping them to resist diseases of a fungoid nature. The manure most commonly used by those not well up in manuring is castor cake and bones which is an incomplete manure as containing a negligable quantity of potash. A well-balanced manure such as your agricultural chemist supplies you with, has its constituents so arranged that each element comes in gradually and simultaneously, and the more this point has been considered the greater the value of the manure in tea cultivation. An ill-balanced manure will stimulate the bush at first and then leave it insufficiently supplied with nourishment. The typical manure generally used is:—

Castor Cake	400 lbs.	
Fish	400 ,,	
Nitrate of Potash	100 ,,	
Sulphate of Ammonia	100 ,,	per acre.

A manure low in nitrogen and rich in potash and phosphoric acid showed a distinct improvement in the crop.

In my strong objection to forcing manures, I am at any rate in good company, for you have only to read Mr. Bamber's report on tea soils to see that he condemns them. From what I hear I am inclined to think that our leading authority on manuring is of much the same opinion also!"

The correcting influence as far as aroma is concerned appears to arise from a sufficiency of phosphoric acid. I would therefore recommend a slow acting manure, which, while being cheap, would be effective in producing both quality and quantity and at the same time help to enrich the soil. The plant food given to the soil would be 81 lbs. nitrogen, 37 phosphoric acid, and 60 potash and when insect pests abound I would recommend the use of Kainit as a cure.

The following mixture has proved very successful in Travancore:—

Groundnut or castor cake meal,	per acre,	10 cwt.
Basic Slag or bone meal	,,	1 ,,
Sulphate of Potash	,,	1 ,,

I do not recommend the direct application of lime. There is a sufficient supply in bone and basic slag, and a judicious application of it to composts will satisfy the needs of the plant.

COFFEE.

POTASH AS A FERTILIZER.

A report of the French Consul in Brazil, on the state of trade in that country, contains the following figures of the world's production of coffee in the year 1900-1901. The total amounted to 15,460,000 bags of 132 lbs. each. Of this quantity 11,500,000 bags were grown in Brazil, 1,150,000 in Guatamala, Costa Rica, Mexico, and Nicaragua, 1,050,000 in Venezuela, Columbia, Equador and Peru, 480,000 in the Dutch Indies, 450,000 in Hayti, 315,000 in British India and Ceylon, 200,000 in Puerto Rico and Jamaica, and 90,000 in Padang.

A native of Abyssinia, where it is called 'Boun,' the plant was first cultivated there, and carried across to Arabia in course of time. The Dutch took beans to Batavia and succeeded in growing excellent coffee, with the result that at the present day 480,000 bags are produced in that locality. The Dutch sent a plant to Amsterdam, which was presented to Louis XIV., and from the berries of this the French Colonies were supplied. From Martinique plants were taken to Central and South America, and now Brazil supplies nearly 75% of the world's coffee.

The plant is grown between the tropics, but, near the Equator, principally in mountainous regions.

The virgin soil of the province of San Paulo has such enormous crops that the price of the berry is influenced and almost regulated by its production.

But even in this fruitful region the harvest will lessen rapidly unless the soil is enriched once more by fertilizing.

Hughes calculates that a crop of 7 cwt. per acre removes from the soil :—

Nitrogen	20·9 lbs.	Potash	23·3 lbs.
Phos. Acid	3·7 „	Lime	7·2 „

Although this analysis points clearly to the predominance of potash in the berry, the extraordinary thing noticeable is that so little attention is paid to this by a body of men such as our coffee planters, known to be intelligent, active, and industrious.

They have followed one another for years in supplying bone and castor poonac to the soil, perfectly oblivious of the necessity of a complete manure for the fields. That ruin has not come upon them is due to the fact that they get in the bargain what they never demanded, viz. a small percentage of potash with the nitrogen in the oil-cake. In South America, to which reference is so frequently made by planters, maize was long grown merely to be burned down to supply potash to the coffee plantations.

The variation in coffee (and to a certain extent its price) must be due to the composition of the berry, and it is strange to find capable men of grit and brains omitting a regular analysis of the coffee sent home. It would not be difficult, by a comparison of the annual analyses, to arrive at a correct conclusion as to what ingredients increase and what decrease the value of the produce on the market. I do not think I am far out when I say that the berry suffers from a want of potash, but more so from an accumulation of soda, on which the plant feeds in the absence of a sufficient supply of potash. At the same time, owing to the ill-balanced food placed at its disposal, an inability arises to assimilate a sufficiency of the nitrogen contained in the manure, and the unassimilated portion is merely a waste washed down in the drainage. There are easier ways of getting rid of money.

In Otto's Agrikulturchemie, pages 226 and 227, treating of the laws that regulate the assimilation of food by plants, he says :—" Many plants have the power of assimilating, by degrees, certain ingredients, even when these are present in small quantities; as, for instance, maritime plants collect the iodine contained so sparsely in the sea water, to such an extent, that it can be extracted from their ashes. But, following the law of Diosmose and the consumption of substances in the plant, one can explain how the composition of the ashes of individual plant species can still change, to a certain extent, according to differences of soil and varieties of manuring. For example, one and the same plant will contain a difference in the proportion of its ash-constituents as it is grown on a soil rich in potash and poor in lime or on a soil fairly rich in lime.

Similarly, in artificial soil mixtures, certain plants, e.g. turnips, show the same differences, if, in one instance the soil is manured with little potash and much soda, and, for the sake of comparison, another is treated with much potash and little soda. The plants grown on the first field will contain more soda in their ashes, while the latter, on the other hand, will contain more potash. There is nothing remarkable in one metal partially taking the place of another in the ashes of plants. On the contrary, it must appear a matter of course, when one bears in mind that the acids demanded by plants as important means of nourishment, such as phosphoric, nitric and sulphuric acids, that can be only taken up into the plant in the form of salts, are found in combination, at times with more lime, at times with more potash, or some other base. Should the plant in question require one or more of these acids in a specially great measure, it will make use of only one part ot the quantity of salt-like compounds, the real acids which are worked into the sap by the cells and changed into other substances, while the basic parts, taken up at the same time, accumulate somewhere in the plant without being used as such in the compound."

In the "Annales de la Science Agronomique Francaise et Etrangere, Neuvieme Annee, 1892, Tome 2, Etude sur quelques station agronomique Allemandes," pages 324 *et seq.*, in the discussion of the fertilizing effects of nitrate of soda as compared with sulphate of ammonia, when treating of Professor Wagner's experiments with these, we find:—"It has often been advanced that manures containing salts of soda render the phosphoric acid and potash of the soil more capable of being assimilated and also tend to render the growth of vegetables more active and to increase the returns of the harvests. Professor Wagner does not deny this dissolving power of soda but does not believe it has the influence so often attributed to it, nor does he allow that the good effects obtained are due to the use of salts of soda as a manure.

The experiments of growths in sand and water prove that plants have no need of soda for their normal development. He was able nevertheless to show that soda favoured certain phenomena in the nutrition of plant-life; for it may be in a condition to take part in certain functions, which, in its absence, are carried on by potash alone. This reciprocal replacement of the chief minerals is not a mere hypothesis purely gratuitous.

Emile Wolff has proved that Silicic acid, for example, is able in certain cases and to a certain extent, to be a substitute for phosphoric acid. There is consequently nothing astonishing in the fact that soda behaves in a similar manner with reference to potash ; but it is permissable to judge, *a priori*, that if any such substitution is possible, it is only partial, because plants absolutely require potash to enable them to live. It was to verify these hypotheses that Professor Wagner undertook these experiments. From a study of them we come to the conclusion that, in soils relatively poor in potash but containing all the other constituents of plant-food, in sufficient quantity, the cause of the superiority of the Nitrate of Soda over Sulphate of Ammonia is due to the soda carried into the plant at the same time as the nitric acid by the nitrates. In soils sufficiently rich in potash the two salts produce effects which are equal. The action of the soda is illustrated by the contents of potash and soda in three harvests.

1. If sulphate of ammonia produces an increase of return equal to 100, it takes from the soil 5 grs. of K. O.

2. If sulphate of ammonia plus muriate of potash produces an increase equal to 132, it takes 5 grs. of K.O. from the soil and 6·6 grs. of K. O. from the manure.

3. If sulphate of ammonia plus common salt produces an increase equal to 147, it takes from the soil 6·6 K. O. and 12·4 of Na. O. from the manure.

4. If nitrate of soda produces an increase of 137, it takes 4·7 of K. O. from the soil and 12·7 of Na. O. from the manure.

5. If nitrate of soda plus muriate of potash produces an increase of 160, takes 4·7 K. O. from the soil and 6·1 K. O. and 11·4 of soda from the manure.

In other words :

1. In soils not relatively rich in potash, soda exercises a favourable influence decidedly marked in the development of plant-life. Such soils are in fact able, whilst utilising the same quantity of potash, to produce harvests half again as great when treated with common salt.

2. Without being able to completely supply the place of potash, soda is still able to replace it to a certain extent. The experiments show two increases in harvests, almost equal (132-137), which contain vastly different quantities of potash and soda.

3. Soda determines a better utilization of the potash of the soil which is at the disposition of the plants. Messrs. Champion and Pillot, in their many analyses of vegetable ashes placed before the Academy of Science, have shown that the mineral bases can, to a certain limit, reciprocally replace each other in the accomplishment of the vital functions of plants, but they have not deduced from their observations any practical rule concerning the employment of the manures.

From what we have seen it follows that two unequal quantities of nitric acid helped by equal quantities of soda produce the same effects. To find an explanation of this seemingly paradoxical fact we must consider the co-efficients of utilization.

An examination of the results of the experiments alluded to above also proves:

1. That potash and soda, whilst favouring the growth of plants, help to a better utilization of nitrogenous manures.

That, under the influence of soda, the co-efficient of utilization of the nitrogen of sulphate of ammonia can equal that of nitrate of soda, though, as a rule, it proves inferior by 10 or 15%,—in other words, the plants which have received nitrate of soda and those which have received sulphate of ammonia plus soda absorbed almost the same quantities of nitric acid, though different quantities were placed at their disposal.

Mr. Warrington made two series of experiments, in the one of which, half the plots were fertilized with nitrate of soda and the other half with the same quantities of nitrogen in the form of sulphate of ammonia. In the other series the plots were similarly treated but they received, in addition, phosphates and salts of potash. The result proved that the application of potash increased the effects of sulphate of ammonia just as an addition of soda would have done. Warrington explains the superiority of nitrate of soda by saying that it exercises a dissolving action on the principle plant-foods of the soil, and renders them more easily assimilable. What we have said of the role of soda shows that this explanation is not correct.

Nitrate of soda is superior to sulphate of ammonia not because it renders the potash of the soil more assimilable but because the soda is absorbed by plants and is able to carry out such vital functions as those for which potash is not indispensable."

I have laboured this point because

1. Every planter ought to know the necessity of potash for all plant-life.

2. The very analysis of the berry shows the needs of the coffee bush.

3. The use of potash helps to a better utilization of nitrogenous manures.

4. Practically no potash, save the small amount found in castor cake, has been used as a manure on coffee fields in India.

5. The plant should be prevented from taking up too much soda, which will occur in the absence of a sufficiency of potash.

6. The soda contents very probably lower the taste and the price of the berry, and it is time that a thorough enquiry be made into this question.

A planter in the Shevaroy Hills sent a question to the Presidency Manure Works, Madras, which at first appeared a decided puzzle. He was a careful man, who knew his work and found his coffee plantation in apparently the best order, the bushes in prime condition and bearing heavily. Yet the price the berry fetched was remarkably lower than formerly. Other planters may object that the question was simple and explain it by the produce of Brazil, etc. These were evidently points known to and not forgotten by the Shevaroy planter. It so happened that he had kept various analyses of his produce with the prices fetched,and a study of these could lead to no other conclusion than that variations in price accorded with the variations of potash and soda contents, falling with the fall in potash and rise in soda, and rising with the increase in potash and the fall of soda. There are no doubt many estates carefully manured with bone and castor cake and, perhaps occasionally, with nitrate of soda. These will probably show well-preserved bushes bearing fairly well. Is the price the same? Is the falling price entirely due to over-production in Brazil? Or has East India coffee lost its former pre-eminence on the home markets? Another question on manuring, that ought to exercise the minds of owners and managers of coffee estates, is the introduction of super-phosphate to take the place of bonemeal as a manure. There is not an over-abundance of lime in coffee soils, and it does not appear wise to introduce sulphuric acid, which, uniting with the available lime, changes it into gypsum. Dr. Aitkin knew the full meaning of what he said, when, in addressing the Fife Farmers Club, he warned them against sulphuric acid, assuring them the less they used of it the better it would be for them at any rate

Experiments carried out under the most varying circumstances in countries wide apart, alike at experimental stations and on immense estates, all prove the utility of bonemeal and potash as a good fertilizer for coffee.

Whether tried at the Horticultural Society's Gardens at Calcutta or on the vast plantations of Brazil, phosphoric acid, in a form not too soluble, in other words, bonemeal, proves an excellent manure, especially if aided by potash. The latter, besides acting as a fertilizer itself, hastens nitrification, and thus the plant is provided with its chief food constituents, nitrogen and phosphoric acid from the bone, and potash from either kainit, muriate or sulphate of potash, and all these foods are supplied at one and the same time.

There is scarcely a European planter in the country, but has his own theory about manures; but in all the correspondence to be found in the planters' newspapers, the war seems to wage invariably on the excellence in utility or the harmfulness of a fertilizer containing one or at most two of the chief constituents of plant-food. It is seldom we hear of the use of a complete fertilizer. From Guatemala we have the records of experiments carried out on the estate of an experienced German planter, and his words might carry some weight in India. He says: "Phosphoric acid increases the bearing but, if applied in large quantities in an easily soluble form (such as superphosphates), it gives an excellent return for one or two harvests and kills the plant." Potash shows its effects on wood and leaves. In the Fincas the adjoining fields are burnt, and supply the requisite manure. But if this be not done, the want is quickly noticed. Nitrogen produces strong, fleshy branches, wood and dark leaves, but causes the fruit to be long in ripening.

Lime unites for a time the properties of potash and phosphoric acid. Like potash it produces long woody branches, and like phosphoric acid it causes an early ripening of the fruit, and decomposes the soil.

The success of bonemeal with coffee is endorsed by almost every planter. The Secretary of the Horticultural Society of Calcutta, shows results far better from bonemeal than Guano could show.

Unfortunately coffee is not very widely grown in India and planters have been so badly hit by the fall in prices that they fear to add anything to their expenditure, forgetful that the addition brings with it a compensation in increased returns and an improved soil.

When prices have fallen in the decade 1897 to 1907 by nearly 40 per cent. it seems a cruel cynicism to suggest further expenditure. But there need be none if the manures are only properly balanced and the experiments carried out on a small scale at first. The amount of phosphoric acid, after years of manuring with bone, must be fairly large in the soil and no harm would result by a diminution of this plant-food in the manure and an addition of potash of an equivalent price. After results from these special plots have been tested and proved satisfactory, it may be found useful to spend slightly larger sums on the very necessary potassic ingredient that helps to form a complete fertilizer.

Comparing Bell's analysis of Mocha and East Indian Coffee, raw and roasted, there are two points that especially attract our attention, viz., the greater amount of nitrogenous or colouring matter in the alcohol extract found in Mocha (amounting to 2·59 per cent. in the raw and 1·47 in the roasted), and the smaller amount of albumen which is 1·36 in the raw and 1·90 per cent. in the roasted coffees.

The caffeine and caffeic acids are practically the same in both coffees roasted, there is little difference in the saccharine matter when roasted, the dextrine scarcely varies, and the difference in the ash, as also in the moisture is slight.

Experiments tending to increase the alcohol and lower the legumin (albumen), may bring about analyses which practically agree, and it is possible thus to raise the value of East Indian coffee to the level of Mocha.

Bell's analysis :—

Constituents.	Mocha. Raw	Mocha. Roasted	East Indian. Raw	East Indian. Roasted
Caffeine ...	1·08	0·82	1·11	1·05
Saccharine Matter ...	9·55	0·43	8·95	0·41
Caffeic Acids ...	8·46	4·74	7·58	4·52
Alcohol Extract containing Nitrogenous and colouring matter ...	6·90	14·14	4·31	12 67
Legumin or Albumen.	9 87	11·23	11·23	13·13
Fat and oil ...	12·60	13·59	11·81	13·41
Dextrin ...	0·87	1·24	0·84	1·38
Cellulose and Insoluble colouring ...	37·95	48·62	38·60	47·42
Ash ...	3·74	4·56	3·98	4·88
Moisture ...	8·98	0·63	9·64	1·00

To the planter on the west coast who dreads the few days between flowering and fruiting when rain is badly needed, I cannot too strongly recommend a combination of castor cake and of bone and potash salts, as the last will absorb any moisture in the air, and draw up the moisture from the soil below and bone retains the moisture longest of all mineral matters in the soil. It should not want much to convince the planter of the utility of muriate in this respect as it contains 7 to 20% of chloride of sodium or common salt and 52 to 56% of potash. The potash has been proved to accelerate the decomposition of bone, and both combined have an advantage such as few manures can show, viz., they present to the plant all the three necessary food ingredients at the same time and in a very well balanced proportion.

In treating of coffee I have not dealt with the cultivation, for experienced farmers cannot be taught their own business ; nor have I entered on the vexed question started round the Leeming system, the weeding of gardens, etc.

At the same time I should like to draw attention to an extract from a letter from G. F. Halliley, that appeared in the January issue of the Tropical Agriculturist of the year 1905.

In it he says ;—" Early in the 'seventies' Mr. Crewell sent some ashes of the white weed to Baron Liebig for analysis, and Baron Liebig pronounced them to be the essential food of the coffee tree. Later, when the coffeeplanters wrote to him for a cure for leaf disease, he advised them to grow an intermediate crop, and I advocated that that crop should be the essential food of the coffee tree, the white weed."

It would be interesting to learn more about this weed, and how far it serves in place of a rotation on the land, whether both the weed and the coffee improve when grown together, and if the presence of the weed is a preventive against leaf disease. It is a pity that nothing further has been done so far to elucidate so important a question.

My object has been, as in all the chapters dealing with Manurial Problems in India, to restrict myself to the question of manures, and, in treating of fertilizers for coffee, I very naturally drew attention to the necessity of potash in a complete manure, its utility in helping plants to assimilate nitrogen and the important question of the amount of soda taken up by the berry in the absence of a sufficiency of potash and the still more important point as to the variation in the taste and price that may be due to an increase in the soda contents and a diminution of the potash.

It is to be hoped that planters will seriously consider this last point and insist on analyses that may cause its elucidation.

THE COCONUT.

MANURE AND TILLAGE.

There is scarcely a tree so common along the shores of India, whose very position almost cries out to the peasant the quality of food it requires, and yet, the moment we leave the strand and find ourselves some distance from the sea, though the palm is still grown and a plantation looked upon as a family insurance, so little is done to obtain from it anything like the best return. It has been said that the banana is a curse, for its plenty generates idleness. The ability of the coconut to thrive with so little attention may similarly be held answerable for much of the poverty we see around us. Enough comes in without bother, why should the philosophic Eastern worry about making more. And yet there is not a coconut palm plantation in India that yields what it could be made to yield. The fact that the palm grows often where its roots are washed by the sea water, and that near the seashore it grows best, should point to its greediness for common salt. This is corroborated by the analysis of the coconut made by Dr. Bachofen, the chemist in charge of Mr. A. Baur's Laboratory in Colombo. In the supplement to the *Tropical Agriculturist*, February 1st, 1901, we find the following:—" On reading through the figures of Dr. Bachofen's analysis, the most remarkable facts are the large percentage (1) of potash (30·7 per cent.) and common salt (45·95 per cent.) in the ash of the husk; (2) of potash (54 per cent.) in the ash of the shell; (3) of potash (45·8 per cent.) in the ash of the kernel; and (4) of potassium chloride (41 per cent.) and common salt

(26·3 per cent.) in the ash of the milk. Calculating the quantity in pounds removed by a thousand nuts (assuming that the entire produce of nuts is removed off the land) we find that the following are the figures for the chief ingredients of plant-food :—

Nitrogen	...	8·6	lbs.
Phosphoric acid	...	2·4	„
Potash	...	18·7	„
Lime	...	2·3	„
Common salt	...	21·4	„

It is perfectly plain that common salt and potash are badly needed by the coconut. Now kainit contains 12 per cent. pure potash and about 36 per cent. chloride of sodium or common salt ; so it is clear that there is not a better manure for coconuts than this combination of common salt and potash in kainit. The analysis also shows the necessity for a certain amount of lime, phosphoric acid, and nitrogen, plant-foods that are all contained in bone. It so happens that potash has been found by practical experience to help considerably in the decomposition or nitrification of bone, and consequently I consider the mixture of bonemeal and kainit the best manure for the coconut, as it will supply at the same time and in the same place nitrogen, phosphoric acid, lime, potash and common salt to the roots of the palm, giving it, in other words, all the plant-food it requires in the best balanced proportions.

Wherever the Indian peasant can be shown that there is money in manuring he manures to the extent of his means and proves himself as up-to-date a farmer as any in Europe. He does not know chemistry and he does not want to know it. Pot experiments he does not believe in, nor has he the money to undertake them.

But practical results appeal to him. He does not mind laying out 4 to get 8 annas.

The *Tropical Agriculturist*, dated 1st March, 1902, has the following letters which show that the deductions from the analysis are proved perfectly correct in actual farming :—

THE CULTIVATION AND MANURING OF COCONUTS.

February 11*th*.

DEAR SIR,—In your issue of the 7th instant your Veyangoda correspondent gives the price of coconuts realized at Yakkala Estate, Henaratgoda, the property of Dr. Dias, the retired Colonial Surgeon. Further information regarding this estate will, I think, surprise all interested in coconuts and show to what extent the intelligent cultivation of this palm can increase its yield. The situation of Yakkala Estate, I need not say, is by no means the best district for coconuts, and yet its present yield compares most favourably with the best in the land. In 1896, the Doctor took up his residence on the estate, and for the first twelve months picked less than 70,000 nuts (previous to this the property was on lease to natives) and within five years he has increased the yield to nigh 300,000 nuts, picked from it in 1901, and this from only four to five thousand trees in bearing, or over 60 to 70 nuts per tree. Mr. W. B. Lamont, who is, I am glad to think, still among us, will, no doubt, be pleased to hear that his words uttered over 30 years ago have been proved, that "no product in Ceylon responds to, or repays so well for manuring, as the coconut palm." With this I send you a stalk I took off a coconut tree from this estate, of which the spathe had opened and flowers in the stalk set. You will note the thickness of this stalk and the 11 young nuts on it. This bunch had 36 stalks with 2 to 11 nuts on each, and there are several such on the tree with nuts similar to this, and I was informed that over 50 trees on the estate are for the first time showing bunches like this, thus promising enormous increase of yield to be gathered during the current year, which the proprietor estimates from four to five hundred thousand. Here then is a nice little sum to work out. What will 100 acres of coconuts, say with 70 trees to the acre and only 12 spathes per tree per annum (some give sixteen) opening out with 36 stalks and 2 to 11 nuts on each stalk, of which say only four nuts arrive at maturity, (and there are already trees with that number of matured nuts) give per acre? I don't wish to put the answer on paper for fear the result of its publication may start some blight on the coconut palm. I send you for the purpose of being better able to follow what I have said, a bunch taken from a native garden on which you will see there are 41 stalks, and only 18 of these with one nut on each as you find on ordinary trees. Compare the size of the stalks on this with that on which there are 11 nuts. The proprietor is of opinion that salt, especially mixed with other fertilizers, is the great desideratum, and he uses the ordinary culinary salt to the extent of 2 lbs. to each tree in spite of its cost, and he is very wroth with the Government for not making it more readily available for purposes of agriculture and the cultivation of coconuts in particular. The proprietor says he is not yet in a position to speak with certainty as to what is the best fertilizing mixture for coconuts, but hopes to be able to do so two years hence.

Yours faithfully,

(Sd.) COCONUT PLANTER.

No. II.

February 8th.

Sir,—"In the history of the coconut industry, have the prices ever reached those ruling at the present time? What is the reason for the present prices? Is it that the demand, by leaps and bounds, outstripped the supply, in spite of the large areas annually coming into bearing in Ceylon and in the Straits, and I suppose in other coconut-producing countries as well? These are a few questions that arise in the minds of coconut planters, and I suppose in the minds of others as well. I have heard it suggested that the war in the Philippines is the chief cause of the rise in the coconut market. I shall feel obliged by your publishing a table showing the areas under coconut cultivation in different parts of the world, with the produce of the trees and the value of the exports. This seems to be a tall order, but for one with an encyclopædic knowledge such as you possess, it will not be so.

Whatever the cause, the fact remains that prices are in the ascendant, much to the benefit of those interested in coconut cultivation. The ruling price of copra at this time last year was Rs. 47. I see it announced in the papers that a parcel of copra fetched Rs. 66. That means Rs. 19 above the market price at this time last year. Of course, there is a corresponding rise in the price of nuts.

With the price now ruling for coconuts the estates market ought to command encouraging prices. I see a little correspondence in the papers about the price the well-known Kirimitiana Estate ought to fetch. As a rule, those wishing to buy a property at an auction sale do not publish to the world the price they are prepared to pay for it."

(Sd.) Marawila.

Nothing more need to be said about the value of coconuts and coconut growing after what we find written by old planters in Ceylon. As to the manuring part of it, if common salt can give such returns as are detailed in the first letter, one feels backward to calculate what would result from a more complete and well-balanced manure. As with the cotton of the United States and the sugar from Java, it will be hard to obtain credit with the natives of India till the experiments are tried before their eyes. There are numbers of wealthy Indians who invest in farms in the country while pursuing their ordinary business in towns. If these hard-headed capitalists would only open their eyes to the advantages obtainable from land that scarcely pays them now, and begin with experiments on a limited scale, the whole country would soon be following in their wake, and they would deserve well of the Government for benefiting others immensely whilst adding to their own incomes.

MANURE YOUR COCONUT PALM.

Under this heading, an esteemed correspondent sends us the following valuable particulars, says the *Ceylon Catholic Messenger* of October 14th, 1902.

"There is a coconut estate in Heneratgodde which it is worth while to look at for those who are engaged in that occupation. The soil is generally hard and composed of hard gravel, except as usual in the Agras. The trees stand some eighteen feet apart, some twenty, and some twenty-four. Almost every tree bears its indelible marks of early neglect. When the present proprietor took the estate in hand, some six or seven years ago, the average yield per tree was ten nuts in the year. This can be readily believed when you look at the trees on the surrounding estates. For, they are certainly capable of yielding more than ten nuts. By persistent manuring the present proprietor of the estate of which I speak has raised the average, step by step, to something over fifty nuts already. He is not likely to stop until he reaches the round hundred. I have obtained an average of 135 on an average experimental block of two and a half acres, where the situation, soil, age and distance between trees are all more favourable. Some of those trees have given me more than 200. An average of 100 is therefore no impossible result for a proprietor who manures.

According to general experience a weak tree standing in the midst of strong healthy ones never regains its strength so as to bear as well as its neighbours. What I saw on the Heneratgodde Estate seems to be exceptional. A weak tree, standing among and having a trunk the circumference of which is scarcely one-third of that of its neighbours, bears here as well as they.

The cost of the manure used and its application cannot be computed at less than one rupee per tree, which represents the value of 25 nuts. Anything therefore that a tree yields over 35 nuts must be put down as clear gain. Add to it the gain from the breeding of cattle, deer, sheep, peafowl and bees which takes place on the estate, and no proprietor has cause to grumble over the smallness of the return from the coconut as compared with other industries. The worst that can be said against the coconut is that it takes some 25 to 30 years to bear on hilly ground, though it flowers in the fifth year and brings a good income about the tenth year in lowlands composed of alluvium.

In Jaffna and Batticaloa it is usual for the natives to manure and plough their coconut estates. In the Colombo district only a very limited few do it. It is a means of quadrupling the income of one's estate. But here one prefers to extend one's acres instead of increasing the yield by manuring and ploughing a limited area. There seems to be no remedy for prejudice."

"B" writing in the *Tropical Agriulturist* of Colombo, January 1st, 1903, says :—It is an axiom in agriculture to conform as nearly as possible with the natural conditions under which a product grows, when its cultivation is engaged in.

Now what are the natural conditions under which the coconut palm grows? Its original habitat was the seashore on which the nuts were thrown by the action of currents and waves.

The conditions under which the tree grew and flourished were on a free, sandy soil, highly impregnated with salt and in an atmosphere that was salt-laden.

The extent of land that answers these conditions is limited, and as the coconut industry is a sure and certain one, and does not partake of the nature of gambling as some other industries do, the cultivation of the palm is carried further and further away inland, and it is removed further and further away from natural conditions under which it grew.

According to my thinking, the first and foremost aim of the coconut planter should be, under these altered conditions, to conform as nearly as possible with the natural conditions under which the palm grows. Here he will find scope for the exercise of intelligence and ingenuity. If he has a stiff, clayey or gravelly soil to deal with, he cannot make it sandy ; but it is possible for him to make the soil sufficiently free to allow of the free passage of roots through it. The first operation should be deep draining. The free passage of water and air through a stiff soil will help to gradually alter its texture. The drains should gradually be filled up with coconut branches and bushes, first, along the line of a road. The drainage of the soil will not be interfered with by packing it with branches till such time as the bushes are thoroughly decayed and from a compact mass. This will take many years, by which time, the roots of the palm work their way through the soil to water saturated with decaying bushes, which cannot but add to its fertility.

Another operation far more necessary than draining is to keep the soil round the trees in a thorough state of cultivation. If this can be undertaken when the plants are young, the benefit to the resulting trees will be very great. The large foraging roots will be helped to leave the surface of the ground and to obtain water for the use of the tree from the soil where it is permanently damp. Rain water will percolate through the soil, and there will always be moisture for the roots to draw upon in a season of drought. The feeding rootlets will have unrestricted liberty, and manuring operations in later years will not be costly. If the tilling of the soil should take place when an estate is young, the circle tilled should be enlarged annually till 8 or 10 feet radius be reached. I am inclined to the opinion that with the surface round a tree kept in thorough cultivation by tilling and mauring, ploughing will not become a necessity.

Where tilling of the ground round trees is undertaken in later years, I would suggest a complete turning over of the soil, so that the rank growth of grass, always, to be found on a heavy soil, be turned into the soil. The benefits of green manuring will be attained by this. This will of necessity result in the cutting of the roots of the tree. Some people object to this, and think it will be harmful to the tree and injure the roots. The harm will be temporary, the gain from the operation of tilling will be enduring. I do not feel any squeamishness in injuring the roots of the coconut palm. Observation will show that the bole of the tree is constantly putting out new roots to replace those that are injured, which generally die.

I am of opinion that the roots of the coco palm have no functions to perform on the surface of the soil, and that they are there by reason of the mechanical condition of the soil not permitting them to be where they should be, deep down below the surface of the ground performing the functions of pumps. A coco palm has no tap-root, and the main roots, I am inclined to think, perform all the functions of the tap-root. Observation induced this belief in me. The lateral or main roots of trees, generally spread out parallel with the surface of the soil and horizontally. The main roots of the coconut tree have a downward direction, and in a sandy soil, as in its natural habitat, they generally go deep down in the soil. They are found on the surface, only when the condition of the soil does not permit them to go where nature intended they should be. I think it is for this reason, want of sufficient moisture, that the branches and fronds of young trees growing on a stiff soil, hang down as a rule, while the exception is to find it in a sandy soil, where when it does occur, it is in a different degree. When roots are to be found on the surface of the soil, I think it is evidence that that soil has not been regularly cultivated and is crying out to be.

Observation shows us that the butt-end of the mid-ribs of the fronds of the coco palm is shaped like a spout. During a shower of rain, these catch the rain water, and a stream runs down the stem or near it. I look upon this as a provision of nature to supply the tree with the large quantity of water it requires. The aim of the intelligent cultivator is to store up what nature provides. This is done by thoroughly tilling the ground round the coconut tree, and where the ground slopes, levelling the surface. The necessity for thus conserving the water nature provides will be realized during a period of scanty rainfall. The fronds of a coco palm are so arranged as to thoroughly protect the surface of the ground round the tree, where the rootlets abound, from the direct rays of the midday sun. The arrangement of the fronds also prevents rainwater reaching the shaded portion of the ground. Hence the wise provision of nature to counteract this by the spout-like shape of the butt-ends of the fronds. As I said before, the aim of the planter should be to prevent the water provided by nature going to waste, by tilling the surface of the soil round the trees."

As the correspondence on this subject is frequent and long-continued, I have no hesitation in extracting letters from the paper as they are written by practical planters, of long experience.

DEAR SIR,—In my last communication (in which, by the way, "husks" was made to read "bushes,") I pointed out how one of the natural conditions under which the coco palm grew—a free soil—could be imitated by draining and tilling. In this communication I intend to dwell on the necessity of salt for coconut cultivation.

As I am very strongly of opinion that salt is an absolute necessity in coconut cultivation, especially in inland districts having a heavy soil, I started an agitation for its issue at special rates, about fifteen years ago. It was met by the stereotyped reply. Of the benefits of its use in coconut cultivation, one reads occasionally in the papers of the experiments being carried out by Dr. Dias at Henaratgoda.

It was argued by Dr. Trimen at the time of my agitation, that as analyses showed that the coco palm yielded but a small quantity of salt, and as this small quantity was very likely deposited during the monsoons, salt was not so great a necessity for coconut cultivation as I wanted to make out. I think his reasoning was fallacious. The quantity of any inorganic matter in any product should not determine its necessity or otherwise. Besides, salt has other properties than manurial. It acts chemically and mechanically on a soil. It keeps the soil moist by absorbing the moisture of the atmosphere. It acts as a solvent and renders available the insoluble plant-food in a soil. Lime does not occur largely in vegetation, yet soils are limed to improve their chemical and mechanical condition. Dr. Trimen was evidently misled by Lepine's analytical tables. Cochran, a few years ago, showed that they were wrong as regards the quantity of salt in the husks of the coconut. He was also surprised to find that the husks of a coconut grown on an estate at Kurungala yield more salt than in one grown on the seashore at Kolluptiya.

Of all coconut planters, the late Mr. Davidson was, perhaps, the most intelligent and the one best versed in Agricultural Chemistry. His pupil, Mr. Jardine, is a worthy successor of his. He wrote in 1861 :—

" A tree requires annually 1·34 lbs. salt and 9·79 lbs. potash (according to Lepine's analyses,) yet the larger amount may be less essential to its welfare than the smaller quantity, because this possesses properties which the other has not, and for the want of which nothing else will compensate. The weight of the salt required, compared with the other inorganic matter, does not exhibit fairly its relative value as a manure. Here (Jaffna) day after day may be seen strings of carts creeping from the beach to the estates laden with sea weeds. For the sake of the salt it contains we drive a cart-load of matter which we could obtain much nearer home and at a tithe of the cost, because our Rulers persistently refuse to allow us at the price they sell it for exportation, to purchase that salt for our estates, which it sometimes costs hundreds of pounds to destroy. The following offer was made to Government. Parties to get salt at export price, would adulterate it with matter best adapted to render it unfit for culinary purpose, in the Government stores. They would enter into a penalty bond to the full value of the salt, at the market price, that it should be used solely as a manure for coconut trees and they would pay a Government employee who should certify to its application as specified. We deserve, perhaps, that our want should be disregarded, for, I do not remember that coconut planters have ever combined to have them fairly represented. With more of unity and combination in our efforts, we should doubtless command success".

Possibly at the time Mr. Davidson wrote the above, coconut estates regularly cultivated existed only in the Northern and Eastern Provinces. Though the cultivation of the palm and the opening of estates have increased by leaps and bounds since then, the deplorable want of unity and combination which we then bewailed, still exists. If so shrewd and intelligent a planter as Mr.

Davidson thought salt a necessity in coconut cultivation, and placed so high a value on it, even on the sea-border, surely I was right when I, ignorant of his opinion, advocated the use of salt for coconut cultivation, especially in inland districts. If salt be available at cheap rates, its use will gradually extend, till it assumes very large proportions. When one's neighbours see the benefits arising from its use, they will gradually follow suit. If nursery plants, before being put out, are steeped in brine, they become immune from the attack of white ants, and turn out healthier and stronger plants. If a small quantity of salt be sprinkled in coconut holes, insects are destroyed. If a sufficiency of salt be used to impregnate the soil, the plants will be able to resist droughts, as the impregnated soils will absorb moisture from the atmosphere. If salt be applied to coconut plants of larger growth and to trees, the soil is kept moist and free, if mulched simultaneously, the capillarity of the soil is increased and evaporation lessened, so that droughts will not seriously affect them. Salt, as stated before, is a solvent. When the soil is moist and the plant-food is rendered soluble, rootlets will be performing their functions of feeding continuously."

Most farmers are aware that salt possesses valuable manurial qualities in connexion with some soils, but its application has not been nearly so extensive as is desirable. Salt consists of two-thirds chloride and one-third soda and as the solvent powers of chloride are enormously greater than those of rain water, its ability to break up soil aud leave its constituents free and available for nourishing the roots of plants is a highly valuable qualification. Salt absorbs moisture from the atmosphere and helps to retain it in the soil, thus compensating, to some extent, for a deficiency of rain and it also purifies and decomposes inert matter. When used in connexion with stubborn soils they are made easier to work, while, at the same time, it is of material assistance in helping to destory wireworms, slugs and other insect pests. Salt is specially valuable for sour pasture lands, its actions being to make the grasses sweet and palatable for stock.

In September 1904, J. W. Thurn, writing from Honolulu, says: "In the April issue of your paper recently to hand I noticed an inquiry as to the benefit an application of salt has, on the growth of coconut trees at an altitude. For the benefit of "B" the party inquiring, I would state that at an altitude of 1800 feet my coconuts treated with salt were seven feet higher at the end of the second year than those untreated. Salt was applied when they sprouted."

Certain fertilizing materials, particularly kainit and nitrate of soda, possess well-recognized insecticidal properties. The most important secondary effect of fertilizers is exerted on the water content of soils. To this the increased drought-resistant powers of soils fertilized with certain mineral salts is due. Nitrate of soda and kainit both materially increase capillary action in soils. More water moves upward from the lower strata and thus comes within reach of the roots, when the soil has been fertilized with either of these materials, because the moving water has become a dilute solution of these salts. This fact is not only susceptible of scientific demonstration, but accords with practical experience. Growers frequently explain their observation on this point by the supposition that these materials absorb atmospheric water, and thus increase the available supply. The real explanation lies in the well of certain salts of potash and soda, to increase surface tension, and consequently the capillary movement of soil water.

This action is so important that it may well exert a controlling influence in determining the selection of the form of fertilizer, when no counteracting objection to the use of the material exists. The influence on the water content of dry sandy soils, is sometimes sufficient to save a crop of fruit which might otherwise be lost.

Organic manures increase the dryness of soils during scarcity of moisture.

The analysis of kainit will show how easily it can take the place of common salt, and the arguments adduced in favour of using chloride of sodium for coconuts will serve equally well for kainit.

Kainit contains : Pure potash 12½ per cent., lime 1·12, chloride of sodium 34·6, sulphate of magnesia 14·5, chloride of magnesia 12·4.

The long correspondence in the *Tropical Agriculturist* showed the interest taken by Ceylon planters in the use of salt and points to the fact that little was known of kainit. " B " writing on March 2nd, 1904, says: " The reasons I have always adduced for the necessity of salt in coconut cultivation carried on away from the immediate sea-border are : (1) that the original home of the coconut is the seashore, (2) that salt has a mechanical and chemical effect on the soil, and (3) that for the above reasons, it is not reasonable to measure the necessity for salt in coconut cultivation by the results of chemical analyses. It is very gratifying to find a confirmation of my views by a high authority, or, to be more accurate, to find that the views I hold on the subject are in accord with those of a well-known agricultural chemist.

In reading "Principles of Agricultural Practice," by Professor Wrightson, I find: "The present form of Mangelwurzel is a maritime plant, the *Beta Maritana*, which grows wild near the coast, in situations where chlorine, in the form of chloride of sodium, is abundant. It is well known that, while, even in inland districts, some twenty pounds of chloride of sodium per acre is yearly brought down in rainfall nearer the coast where sea-freshets are common, a very much larger quantity is yearly poured down over an acre. The Mangelwurzel, being a cultivated form of *Beta Maritana*, appears from long usage to require a large quantity of common salt and the application of this substance increases the yield by many tons an acre, especially on soils of light, loamy character. These cases seem to show that special manures are of use in a manner quite distinct from soil requirements." Again —"Additions of sulphate of potash, sulphate of magnesia and chloride of sodium (common salt) often produce a considerable increase in Mangel, but it is open to the view that the effect is a good deal owing to the common salt, rather than to the magnesia or even the potash."

Some idea may be formed of the amount of saline matter required for a fertile soil, if we consider that it requires 500 lbs. to add 1 grain to every pound of earth, a foot deep in an acre.

Mr. Lepine's tables give analyses of the root, trunk, leaves, *tunics*, peduncles, spathes, and fruit or drupe including husk, shell, kernel and water. To serve our purpose totals will suffice showing the fixed matter drawn up from the soil by a coconut tree during 30 years:

Chloride of sodium	35·134	lbs.
Salts of potash	241·494	„
Phosphate of lime	116·526	„
Salts of lime	92·896	„
Salts of magnesia	0·820	„
Silex	17·200	„

The above is taken from the second edition of an interesting work published in Colombo in 1895, entitled "All about the Coconut Palm" and compiled by Mr. J. Ferguson, Editor of the *Ceylon Observer and Tropical Agriculturist*, as is also the following table deduced from the above which shows the total of inorganic and fixed matter drawn up *annually* from an acre by 75 trees bearing 80 nuts per tree:

Chloride of sodium	100·383	lbs.
Salts of potash	734·524	„
Phosphate of lime	300·025	„
Salts of lime	262·182	„
Salts of magnesia	2·674	„
Silex	45·908	„

It will be noticed how comparatively little chloride of sodium is taken up and on this subject the book above referred to speaks in the most interesting manner. On page 38 of the appendix, we find.—"We all know the nature and some of the properties of common salt. Most of us know that it is essential to the existence of man and of animals; but few know that it is as essential to the growth of vegetables. It is found in all organized bodies, whether animal or vegetable, and acts otherwise than as a mere ingredient of these bodies. Were I to say that it acts as a *stimulant*, I might state what I could not explain, but I could point to its operation in the animal economy, as a proof that it possesses properties, essentially differing from those of any other "salts" ; properties, adapting it peculiarly to a tree in which the ever-circulating sap is perpetually varying in constitution and density. Such being the case, we can understand why the coconut tree thrives best where it feels the influence of spray borne on the wings of the wind. A tree requires annually 1·34 lb. of salt and 9·79 lbs. of potash; yet on the above supposition the latter and larger amount may be less essential to its welfare than the former and smaller quantity, because this possesses properties that the other has not and for the want of which nothing else will compensate. If I am right in this matter, the weight of salt required, (compared with the other inorganic matter) does not exhibit fairly its relative value as a manure. Theory is, here, *apparently* at variance with experience; but only so because a property belongs to salt, of which chemical analysis takes no cognizance. It shows the elements and the proportions of them, in any object; but does not exhibit all the properties of them. Most of those who have carefully considered Mr. Lepine's tables were probably as much surprised as he appears to have been at finding how small a proportion salt bears to the whole inorganic matter in a tree; because observation and experience lead one to anticipate a much larger amount. This is precisely one of those cases in which the man who undervalues theory has the advantage. He can point to experience and say that whether science in general, and chemical analysis in particular, be for or against him, salt is the manure which he *must* have. The late Dr. Gardner used to describe the value attached, in the Brazils, to salt as a manure for coconuts, stating that a man would walk many miles for it, pay high for a load, and then apply it to a single tree. At Singapore the ashes of a plant, rich in salt, are used with extraordinary frequency, and I think that at Batticalloa the ashes of the mandrake are, from the same cause, those which produce the most effect. There, day after day, may be seen strings of carts, going from the beach to the estates, laden with sea-weed, which experience has proved so useful a manure.

Potash is the principal ingredient of the ashes of land plants ; soda of marine plants. Lime results from burning limestone or coral. These three are compounds of insoluble metals and the oxygen of the atmosphere, the combination being soluble in water. The salts mentioned are (with the exception of the sulphates and chlorides) varied combinations of these metals with different constituents of the atmosphere ; and under varied circumstances are, by atmospheric agency, interchangeable the one into the other : compounds of soda into other soda salts, etc. It follows therefore that though we apply only potash to a tree it may soon, under favourable circumstances, be converted by the atmosphere into a nitrate or carbonate of potash ; and so with the others. *Salt alone is necessary* because we cannot elsewhere procure the chlorine to convert soda into salts. The salt, which, after potash, is found in the coconut tree, is commonly known as "bone earth." It is insoluble in water but dissolves readily in any acid such as carbonic acid and even acetic. As an illustration of the solvent power of rain water (which always contains carbonic acid in solution) Liebig mentions that an animal buried on the slope of a hill was examined after some years, when not a trace of bone earth was discovered. When a cemetery in Paris was removed, the fat was sold to be converted into soap and candles ; but the *bones had disappeared.*"

When a plantation of coconuts is made in the interior at a distance from the sea it is customary to throw a considerable quantity, as much as half a bushel of salt at times into the hole that receives the coconut. It is consequently amusing reading to find in J. W. Bennett's "Ceylon and Its Capabilities" a paragraph running as follows : "The Cingalese are so extremely superstitious that they invariably throw a little salt into the holes, before they place the coconut plants in them ......If the salt were omitted they would not expect the plant to flourish."

From the analyses and the succeeding remarks of planters long engaged in coconut cultivation, it is evident that a heavy dressing of potash and a fair allowance of bone or superphosphate are needed by the coconut tree and a far greater allowance of salt than the analyses of the plant itself would lead us to expect. As kainit, one of the potash salts contains from 12 to 14 per cent. of pure potash and over 30 per cent. of common salt, it appears to be an ideal form for potash application.

One must only watch the trees near a human dwelling to see the benefits to be derived from manuring. The splendid appearance of such is accounted for by the natives of Ceylon as the love of the plant for the human voice. The manure from domestic animals and from around the house apparently do not count.

W. B. L. writing on coconut cultivation points to the tree itself as a register of its treatment. He says : "The stem of a coconut tree on poor land forms a complete register of the periods at which manure has been administered, the effects it produced, and the time during which it operated and became exhausted. It contracts under the pressure of want, expands when fed liberally, and again contracts when all the food is used up. There was a tree that had stood for twenty-five years on sand so poor that not a blade of vegetation was ever seen within twenty feet of it ; the stem, over one foot in diameter at the surface, gradually diminished upwards, till at the five feet of height attained, it was less than four inches and the length of the leaves was about thirty inches. In very truth, no more wretched specimen of a still living plant could have been conceived by the mind of man, and it was only for the sake of proving the theory that its treatment was undertaken. Twenty pounds of poonac and five pounds of steamed bones were mixed and sown broadcast in a circle twelve feet in diameter and dug in. It began to grow vigorously at once and each fresh leaf that expanded was an increase on the length of its immediate predecessor till at the end of twelve months they reached fifteen feet ; at eighteen months it produced its first flower and was again manured with five pounds of poonac and two pounds of bones ; at thirty months it began to give a crop and the top was so heavy that there appeared some danger of the small part of the stem giving way, but this did not happen and for the three succeeding years the same dose of poonac and bones was given. At the end of the fifth year it was a handsome vigorous tree, with the stem immediately under the leaves, over one foot in diameter and a crop of from 60 to 70 nuts, while the aggregate of previous gatherings was not over one hundred nuts. I have only to add that the cost of these results was 75 cents (about 12 annas)." There is an old Hindu adage concerning the coconut which runs : " Water me continually during my youth and I will quench your thirst abundantly during the whole course of my life." They might have said appropriately: "Feed me well throughout my life and I shall feed you well in return," though of course irrigation should not be neglected till the tree has reached its eighth or tenth year and in many places throughout the course of its life.

If it be true that, in the whole range of vegetation, there is scarcely a plant that will do so much for itself with so little help, it is equally true no plant responds so much to assistance in the shape of fertilizers.

Manure made by cattle fed on the grass of the coconut field adds nothing to the general fertility of the land; it merely removes it from one place to another; but while the plant is young, and only commands with its roots a small proportion of the space assigned to it, the placing of the manure within reach of the roots in this form is of high importance to its rapid growth and early bearing. It is not the amount of food thus placed within its reach that limits the good done; the roots are stimulated to push out further into the soil and thus acquire a wider feeding ground.

The roots of the coconut are most vigorous and active towards the extremity of the primaries and these qualities gradually diminish towards their origin on the stem, because in their outward course they have already appropriated the cream of the soil's elemental wealth. Therefore, manure in the centre between two lines of trees is more immediately effective than within a few feet of the stem, even if cattle tying in circular trenches be avoided. Tying two head of cattle to the tree for ten nights, what with treading and what with fresh urine, kills off all roots within six inches of the surface, thus depriving the tree of its wider range of feeding ground, and the immediate effect is a falling off rather than improvement. If the dung be dug into the soil at once, the tree revives and flourishes till the supply is exhausted, when it rapidly falls off to a worse state than before the application; but the more common practice is to let it alone. As the feeding roots of plants do their work underground, dung left on the surface is so much good stuff wasted besides injuring the tree by inducing it to throw out primary roots above ground, in an abortive endeavour to reach the food from above, which it cannot avail itself of from below. The planter who uses a complete *manure properly balanced* such as oil-cake or *nitrate of* soda, bone or *superphosphate and potash in the form of* kainit will double, treble, and quadruple the crops of land previously left to the care of nature.

A well-watered and manured tree, in good soil, begins to yield when it is five years old and in bad soil when it is eight or ten years old. It is in its greatest vigour between the ages of twenty and forty and continues to yield till it is eighty, living to a hundred.

As a rule a plant throws out a spathe and a leaf every month : each flowering spike yields from 10 to 25 nuts. The produce of a tree in full health and properly tended may be from 50 to 120 and even 200 nuts a year, the yield depending greatly, of course, on the suitability of the climate and soil for coconut cultivation ; a safe average would be 100 nuts a year to each tree in full bearing. A Ceylon planter says there is no practical limit to the yield, for he knew trees that for a series of years bore 400 nuts and many individual trees that regularly yielded from 200 to 300. Any tree that bears a small crop in any soil may be made to bear a large one in response to the proper manure applied. The natives of India call a coconut tope a bank, but they continually draw cheques on their capital without putting in fresh deposits. The result is seen daily in the decreasing returns.

As in all other cases of manuring it is always better to manure the acre and not the tree, for so many mistakes are made as to where the fertilizer should be placed. If put around or very near the stem of the plant much is washed down into the soil and is lost to the feeding roots, whilst if the plantation has the manure spread over it and ploughed in, every rootlet has an opportunity of receiving its plant-food.

The following mixture will be found useful as an annual application per acre:—

Lime	½ cwt.
Bonemeal	½ cwt.
Kainit	3 cwts.

Ground-nut cake meal 5 cwts., or any other oil-cake provided the same amount of nitrogen is supplied. Fish is extensively used instead of bonemeal and cake, but the analysis cannot often be depended upon.

To owners of coconut plantations I would suggest experiments on a few trees, till, after seeing results, experience convinces the farmer that nothing pays better than manuring coconuts.

POTATOES.

In the Government Report of the Department of Agriculture, Bombay Presidency, for the year 1908-1909 we find a very interesting record of experiments with potatoes. It is a pity the extent of the plots and the variety of the manures used, the cost of culture, and the net profit are not included in the returns—all points of the greatest interest to the Indian farmer. However, the purpose for which the experiments were undertaken appears to have been served and the results may open the eyes of those hitherto contented with what after all must be considered poor harvests.

As it will certainly serve a useful purpose the results are embodied here :—

" This is a very important crop in the neighbourhood of Belgaum and Dharwar. The department has rented a plot of 5 acres at Belgaum and the 1st crop was taken during the year under report. The local cultivators always purchase Italian seed for sowing at Belgaum and the produce of this is sown at Dharwar. Seed cannot be retained from one season to another owing to insect attacks in the stores, which are not well protected.

With the object of ascertaining whether Italian seed is the best for the purpose, a large number of varieties obtained from different parts of India and also from some of the famous European Potato Districts, were grown on small plots, and the following statement comprises those varieties which gave the best outturns :—

Name of Variety.	Register No.	Yield per acre in lb.
Duke of Cornwall ...	79	33,142
Northern Star ...	52c	32,800
Early Rose ...	21c	23,746
Sutton's Superlative ...	73	23,520
Windsor Castle ...	75	22,154
Hymalian Old ...	54c	23,000
Burbank ...	92	20,470
Scotch Champion ...	84	20,000

Besides these a large number have yielded over 10,000 lbs. per acre. It will be seen that the highest yield amounted to about 15 tons per acre which must be considered very satisfactory.

Italian yielded 12,811 lbs. which was considerably less than a large number of other varieties. If these results are confirmed this year, it will be a matter of careful consideration whether some of the best yielding varieties should not be distributed to cultivators and the *latter recommended not to grow the Italian variety."*

There are, however, other factors which have unfortunately to be taken into account, viz., (*a*) insect attack and (*b*) rot. Many of these varieties are subject to rot ; Pachmari, which yielded a crop of 15,756 lbs. per acre was the first to become affected with rot which occurred only a fortnight after the crop was harvested. The English varieties followed suit a little later, but these are more resistant to insect attack in the godowns. It has been frequently observed that varieties with deep-set eyes are most subject to insect attack and this observation was again confirmed this year under report. Most of the English varieties have shallow eyes. Investigations will therefore have to be continued till a good yielding variety, resistant to rot and insect attack, has been found.

At Belgaum, potatoes are grown as a rabi crop, with the aid of irrigation, while at Dharwar they are grown as a rain crop without irrigation. In the year under report, potatoes were grown in black soil (the farm site) and in red soil (Kelgeri site). The produce of the crops grown on these two soils were kept separately until it was required for sowing at Belgaum in the rabi season. It was at this time that it was discovered that the potatoes produced in black soil had begun to rot very rapidly and were also attacked by insects, while the crop produced in red soil, was in sound condition.

An effort was made to introduce this crop upon the Dohad Farm in the year under report and with fair success. It was necessary to sow the seed with only a limited quantity (5 tons per acre) of farmyard manure and on land not previously cultivated for such crops. Fresh Italian seed was used and an outturn of 8,625 lbs. per acre was obtained. The brown loams found in the Panch Mahals are likely to suit this crop well where sufficient manure can be obtained along with irrigation facilities."

The introduction of potatoes from Australia appears to have been followed by a successful culture of the tuber, to judge from the following that appeared in the *Madras Times* of the 23rd February 1910 :—

"It is now seven months since we pointed out to the public, on the authority of Mr. I. Stephens of Ootacamund, the large profit which can be made by the intelligent cultivator of potatoes in the Nilgiris. Mr. Stephens, who has much experience in the matter, published a pamphlet to refute a statement made by the Collector that the production of improved seed potatoes from imported tubers has been a failure. His collection of facts and figures with regard to his own importation of tubers and the crops obtained from them is convincing, and inspired, we hope, many others with the ambition of following in his footsteps. A G.O. has now been published, giving particulars about the most recent experiment in imported tubers. On this occasion the seed potatoes were brought from Australia and the consignment was handed over to Mr. George Oakes and planted out by him in September last near Kulhutty. The crop was lifted on the 10th January and was found to be perfectly mature and free from disease. Mr. Oakes put down 18 cwt. 'Satisfaction' and lifted 73 cwt. ; 8½ cwt. 'Brownell's Beauty' and lifted 35 cwt. ; and 10 cwt. 'Cambridge Kidney' which gave a return of 28 cwt. It is explained that the latter variety was sown in poorer soil ; but notwithstanding the heavy cost of breaking up and manuring new land, the estimated returns after deducting expenses is about Rs. 600 per acre. New imported varieties invariably give small tubers at first, so that these returns will be cousiderably magnified at the next sowing, if sufficient care is taken only to put down the good seed. This condition, as we have said before, is one in which the Indian cultivator often fails, for to him painstaking in small matters is too great a mental effort. However there are plenty intelligent growers on the Nilgiris who may be trusted to take advantage of the new seed within their reach."

If such poor results as the above pay so well, what ought to be the returns from a really good harvest ?

It can scarcely be said that English potatoes had not been tried in India before. A look into the pigeon-holed reports will probably bring to light not only the fact that experiments have taken place, but also the reason why they have not been continued.

In the Agricultural Gazette of New South Wales, September 1903, Mr. George L. Sutton, the Experimentalist, Hawkesbury College, says:—

"*Potatoes from England.*—Twelve varieties of potatoes, which had been presented to the Hon. Minister of Agriculture, by Messrs. Sutton & Sons, the well-known seedsmen of Reading, England, came to hand December 6th, 1902. These varieties had been specially selected to suit Australian conditions. They arrived in splendid condition, all varieties well sprouted, but hardly any decayed or injured ones in the whole consignment. They arrived too late for the early planting; they were, however, carefully preserved and planted as soon as weather conditions would admit. It is to be regretted that shortly after the plants appeared above ground a slight heat wave set in, which proved too severe for these unacclimatised varieties. The whole of their foliage was completely destroyed, whilst that of the acclimatised growing alongside of them was uninjured. This has seriously affected their yields and it also illustrates the value of acclimatised seed."

The best seed should be chosen. The important points to be considered are:—

1. Ability to withstand disease.
2. Increase of harvest.
3. Ability to get large potatoes containing much starch.

4. A better form or shape.
5. Early ripeners.
6. Good-keeping powers.

With the same care and culture the differences due to choice of seed per acre in the harvests have reached 2 tons per acre in Germany.

The experience of potato growers all the world over points to the necessity of careful selection of the most suitable seed. Of course this is quite in accord with the usual principle in dealing with all crops, but as the potato plant has to depend upon its seed for nourishment for a longer period than the generality of plants, all the more care should be taken to have a healthful tuber wherewith to generate a large, paying, healthy crop, hardy enough to be held over for the next planting. Experiments under equal conditions of soil, climate, etc., go to prove that, good seed, soil, manuring, culture, etc., being the same, the harvest varied according to the size of the potatoes sown.

When seed weighing 3·1 to 3·5 oz. were sown, taking 100 as a standard, those weighing 2·3 to 2·5 produced 91·36, and the smaller weighing 1·4 to 1·6 produced 66·54.

About 14 cwt. of sets should be employed as seed per acre.

We see from the Report of the Bombay Department of Agriculture that the selection of the seed has a great deal to do with the harvest return, and that, even with the seed selected, the size of potato planted is equally telling in the crop.

It appears advisable to use medium sizes invariably, for this pays best. However, we must not depend solely on the size of the seed potato. Every farmer knows the importance of tillage, manure, and the suitability of soil and climate. Sooner or later the young plant will have used up all the nourishment contained in the seed and must turn to the soil for support. If then the soil does not contain all the plant-foods necessary for the nourishment of the tuber in sufficient quantities and in available form, it is natural that an interruption in its growth will ensue, and a poor crop will follow.

In its wild state the plant was found in Chili in South America, in Lima, and New Granada, and at high altitudes in a dry climate. Other species were found by Darwin on the sea coast in the Chanos Archipelago, and he notes that "it is remarkable the same plant should be found in the sterile mountains of Central Chili where a drop of rain does not fall for more than six months, and within the deep forests of these Western Islands, the Chanos Archipelago.

Raleigh introduced the tuber into Ireland in 1585 and its cultivation has since spread not only over Europe but all over the globe. Germany alone produced in 1905 no less than 48,000,000 tons.

Here in India it is highly cultivated in the Hughli and Burdhwan Districts where the cultivation is increasing rapidly, in Assam, where two crops are raised in one year, in the hills of the United Provinces, such as Nainital, Almora, Paori, Lorngat, Mussoorie, and in the plains, and about 12,000 acres in the Bombay Presidency, principally around Poona where nearly 90 per cent. are to be found, though small patches are to be seen near Ahmednuggar, Satara, Ahmedabad, and Kaira.

It is astonishing how restricted is the cultivation of the potato in India, when we bear in mind that Hindus eat potatoes on days of fast when grain is forbidden, and it is found to be one of the best paying of agricultural products round Poona.

But to those who blame the natives of India for not accepting plants that are new and apparently beneficial to the rural population, the history of the spread of the potato cultivation in Europe, or rather the diffiiculty of getting the farmers to grow it, will be exceedingly useful reading. Prejudice in this respect is not confined to India.

Already in 1493 Peter Martyr mentioned the potato in a letter to the Archbishop of Grenada. There he calls it agias. The original name was papas, These were dried in the sun and then reduced to meal called Chuna in Peru. The Spaniards termed them Batatas which is the name of the sweet potato. The English twisted this into Potato. The Italians finding them resemble truffles called them Tartufi and Tartufoli, hence the German Kartoffel. Though Hawkins, the slave dealer, introduced them into Ireland between 1545 and 1565, and praised their worth, the farmers of the country would have nothing to do with them, and it was only after they were grown by Raleigh on his farm at Youghal in County Cork, that the people followed the advice to grow them; but as late as 1618 in Queen Anne's reign they were rare enough to cost 2s. a lb.

Even in 1663 the Royal Society in England endeavoured, with little success, to introduce the tuber as a means of fighting famine, but the farmers did not take to the foreign root.

It was as difficult to introduce into Germany as tobacco.

Its culture spread in Bavaria by the end of the seventeenth century: in Baden only about 1740 through the instrumentality of a woodhewer who died in 1803 a wealthy man.

Fredrick the Great knew the value of potatoes as a food during the Seven Years' War, and insisted that the peasants should be dragooned into growing it, with the result that during the famine of 1770, whilst Bohemia lost 180,000 men and parts of Silesia 100,000, in that part of the country where potatoes grew starvation was unknown, although 20,000 immigrants entered it from Bohemia.

Though grown in 1630 in France, its spread was very slow. In 1791 the Academy of Besançon offered a prize for the best substitute of cereals in time of famine. Parmentier got it for his essay on the Potato; but he had to resort to a subterfuge to induce the peasants to take to them. He had it announced all over the country that a severe punishment would follow the theft of potatoes, and then they were stolen and grown over considerable areas; but it was only after the famine of 1793 that the growth of the potato became general.

If in the midst of the boasted civilization of the West it was so difficult to introduce the useful, almost necessary potato, ought we not to think twice before blaming the Indian raiyat because he will not at once take up everything we offer him as tending to his advantage.

The difficulty of conserving and the necessity of importing the seed annually may be one of the reasons.

As might be expected in reading the history of the tuber, it appears to grow best in India at high altitudes as it did in its native home, and there is little wonder that in Mahabaleshwar it grows so large and so well-flavoured. The same is found in the hills in the North-West where the potatoes are so good as to fetch twice the price obtainable by those cultivated in the plains. Even in Burma the same fact is established, the crop in the Karen Hills during 1883 having been nineteen-fold.

When anything is done in India contrary to scientific principles of farming, new comers are apt to jump to the conclusion that the action arises from ignorance. *But the fact is that poverty and the necessity for immediate gain is often the cause.*

Though small potatoes are sown, the farmers know perfectly well that middle-sized potatoes fetch a better price in the market and the money is needed at once. If one took the trouble to explain the advantage from using the potatoes as seed instead of selling them, so that a much larger gain would result when the new crop was obtained, he would probably be met with the vernacular rendering of "Live horse and you will get grass."

Even where for years potatoes have been grown by good farmers, the earth is often removed from the large tubers, while the plants are still quite strong and healthy, and though somewhat immature they are raised and sold in the early market at a high price ; the parts of the plant immediately above the ground are then covered with earth and the fields are watered, so that a second crop of middle-sized potatoes is thus obtained and may be kept for seed.

Though little care is taken in the selection of seed much is done to preserve them.

One of the peculiarities of potato-growing in Bengal is so far not explained by accepted agricultural science.

Not only are potatoes grown in the same field year after year, but experience shows that a newly-broken field does not give a good outturn. Watt in his "Dictionary of Economic Products" states that "potatoes are generally grown after *Aus* paddy as a second crop, but a field which grows only potatoes gives a better crop, and, on such a field, potatoes may also be grown much earlier."

Only experience can show where this practice should cease and rotation or fallow be introduced to avoid the dreadful disease of rot known to the raiyat as *Dhasa*, which makes its appearance just below the ground, causes rot beneath, and dries the upper portion of the plant. Whole stretches of potato-growing fields are completely destroyed by this disease, and the loss is immense.

In Assam it was so virulent in 1887-88 that the crop turned out an absolute failure. Old fields were given up and new seed imported, and in the course of two or three years the disease disappeared.

Here we have a remarkable similarity between a five months' crop and woods of hundreds of years' growth. Foreshadowed by De Candolle and treated of by Jaeger in his "Soul of Plant Life," it was lately scientifically shown in America that plants excrete. Drs. Wilfarth, Wimmer, and Roemer all but came to this conclusion when treating of the action of potash as a carrier of nitrogen, in their book on the "Assimilation of Food by Plants at various Stages of their Growth." In this it is clearly shown that the less potash is placed at the disposition of plants, the more nitrogen returns to the soil. Call it what we like, the matter returned to the soil is an excretion after it has been used in the body of the plant and is got rid of, probably vastly changed, when its work is done. As in animal, so in plant-life emanations are pleasant when not overconcentrated, harmful when there is an accumulation of too much of them. The excreta of plants and the emanations from them are rendered harmless to a great extent by the soil, and by other plants that feed upon their excreta. Certain trees, like the fir and the pine in Europe and the Casuarina in India grow poorly when alone, and reach their proper dimensions only when grown together in numbers. But even these die down in course of time and woods of quite different species follow. To say that they have exhausted the soil can scarcely be an explanation, for they have drawn from the sub-soil the elements of nutrition, and, with the falling needles or leaves, have enriched the humus of the surface on which at least young plants should thrive.

It is evident that a certain concentration of emanations is helpful to such plant-life, but that a time comes when overconcentration takes place, and disease and death follow, and the land is unfit for propagating the same species, though a different tree, that, as in the case of animals, does not find the excreta of another plant noxious, will thrive in its place.

This is the only explanation we can at present find for the improvement of the potato crop and its early maturity on lands where potatoes have been grown before. As with other crops it also explains disease and death from an overconcentration, and it should be the aim of agriculturists to ascertain at what period overconcentration of the effluvia from the roots or tubers of this particular plant is likely to take place.

Dr. Watt says.—"The disease is very probably propagated in the tubers" and though one statement reads "It does not seem that the disease is induced or even influenced by any peculiarities of the soil and climate," what follows seems to point to one of the causes when he says, "if not induced it is much aggravated, by continuous heavy showers and high temperature in the months of Shravan and Badra."

Under such conditions aeration of the soil is practically put a stop to, and the result will be quite in accord with the theory advanced above.

It is very probable that the introduction of charcoal into the manures will help to stave off if not completely destroy the chance of a recurrence of this fell disease. Similar climatic conditions in Ireland have brought about the dread potato blight, and its consequence, famine, and if burning the soil to get rid of the plant emanations be too costly, the cheaper form of deodorising by charcoal would probably have the desired effect.

The Indian peasant is by no means ignorant of the manures necessary to raise a good crop of potatoes. Though he cannot get artificial phosphatic and potassic fertilizers, his choice of such natural manures as are at his disposal are excellent. He applies well-rotted dung, mustard cake, castor cake and ashes, generally preferring castor cake in Bengal, for it contains a fair supply of phosphoric acid and potash, an addition being made to the last named by a quantity of cowdung ashes. Dung is never used unless it be in a well-rotted state, and it is incorporated with the soil long before the potatoes are sown. Green manuring is found only in the best potato-growing villages.

Of course the amount of manures used is regulated, as with every other crop all over the country, not by the requirements of the soil or crop, but by the means of the cultivator, which, as a rule are very restricted.

Generally about 20 maunds (1,600 lbs.) of dung and 8 to 10 mds. (640 to 800 lbs.) of castor cake are used per bigha, and to avoid any loss of nitrogen, half the cake is used at the time of planting and the other half with the second earthing up. At Nalikul, the greatest potato-growing village in Bengal, green manuring is sometimes resorted to, indigo seeds being thickly broadcasted in the middle of May and the plants ploughed in about the middle of July.

The outturn in good years, when sickness has not attacked the plants is about 4,000 lbs. though in some places noted for careful cultivation as much as 6,400 lbs. is obtained. That this return can be very greatly increased is evident from the harvest obtained by Mr. Whitcombe, Assistant Settlement Officer, whose experiments, according to Dr. Watt, in his Dictionary of Economic Products, show a record of 12,000 lb.

Hill potatoes, such as those grown at Mahableshwar, Nainital, Mussooree, etc., are larger and better flavoured than those grown in the plains, but in the North, even these are deteriorating rapidly, and in the South potato disease has shown itself to a great extent in the Nilgiris.

It is to be hoped that the growth of the tuber will spread rapidly in the country wherever the soil allows of it.

Kankar soils (those containing lime nodules) are considered by the natives unfit for potatoes. Iron and saline soils are also not used, a sandy loam of fine texture being regularly chosen.

The following leaflet No. 10 of 1910 was issued by the Department of Agriculture for the benefit of cultivators in the Bombay Presidency :—

" Potatoes are extensively cultivated in the Poona District, and to a less extent in the Satara, Belgaum and Dharwar Districts. They grow well in a good red soil, in a mixture of red and black soil, or in sandy loam. The crop is usually grown as a Rabi crop under well irrigation, but may be grown as a Karif crop where the rain is favourable as in Belgaum.

Cultivation of one Acre of Potatoes.—Get 1,000 lbs. of potatoes as seed. Cut each potato into sets. Cultivate the soil well to a depth of 8 inches, ploughing two or three times. Manure with 30 cartloads of well-rotted farmyard manure. Make a furrow 4 inches deep, plant the sets 8 inches apart, make the next furrow 10 inches from the first, and in doing so the earth will cover the first furrow. Plant the second furrow as the first and continue in this way till the whole field is planted. For irrigation, beds are made 3 or 4 feet wide. Irrigate every 8 days. A dressing of household ashes or crude nitre is very useful. Weed the ground well and earth up the potato plants once when they are 6 or 8 inches high, and again about a month later. Another, and probably better method is ridge cultivation. By this method make ridges 18 inches apart with a small plough and cross furrows 13 inches apart for irrigation and make beds containing four ridges. Plant sets 1 foot apart on each side of the ridge, halfway between the crest of the ridge and the bottom of the furrow. In this way the sets are kept sufficiently moist for germination but are not submerged.

When the leaves wither, watering may be stopped, and when the soil is dry the potatoes may be ploughed or dug up. 15,000 lb. per acre is a good crop.

The crop suffers from two diseases :—

(1) The Ring Disease.—To avoid this, get fresh Italian seed, if possible; and when you cut see that the seed is not diseased. If ring disease occurs in a field one year, do not plant potatoes there again for some years.

(2) The Potato Worm.—The potato suffers much from worms which make holes in them in the store-house and spoil a large part of the crop. These worms come from the eggs which a small brown moth lays on the potatoes. No worms can get at the potatoes unless the moth can get at them. To prevent the moth laying eggs on the potatoes be careful to earth up all the potatoes that may appear above the ground when the crop is growing, and as soon as the crop is dug up, put the potatoes into sacks. Do not on any account let the potatoes lie in the fields at night, or store them in heaps where the moth can lay eggs on them. If you put them in sacks they will be quite safe.

It is probable that potatoes would be found a paying crop in many parts of the Deccan and Southern Mahratta Country where there is good red soil, and in sandy soils in the Konkan. Anyone requiring help to grow this crop should apply to the Director of Agriculture, Poona.

The Potato Worm. (Kare[illegible] Batate Hula.) All cultivators who grow potatoes know the small dirty greyish worm which is found in large numbers in the tubers especially when these are stored for a long time in the godowns. You are all well aware that it is impossible to preserve seed potatoes from harvest time to the next sowing season on account of the damage done by this "worm" and you therefore pay highly for fresh Italian seed imported every year from Bombay. Careful cultivators may have noticed that these worms are first seen upon the leaves while the crop is still growing green in the fields. Afterwards you may have noticed these worms in the green tubers which have become, through accident, exposed to view, but if you look carefully you will never find the worms in the tubers which are well covered up with soil; and the reason for this is that the worm hatches out from the egg of a small moth in the same way that a chicken hatches out from a hen's egg, and, as the moth does not go below the soil it cannot lay eggs on the tubers which are under the ground.

Cultivators are in the habit of mixing all the tubers together at harvest time and this worm spreads from the green tubers to the sound tubers and soon a large number of tubers become infested with "worms."

In a bad year this "worm" will destroy more than a half of the whole produce: a good crop is 400 maunds of 25 lbs. each, per acre, worth at least Rs. 300 at the moderate price of 12 annas a maund; therefore the cultivator loses Rs. 75 per acre.

The Agricultural Department have discovered means of preventing this worm from doing damage to the tubers and good cultivators should adopt the following measures:—

(1) Sow the potato seed deep.

(2) At weeding time cover up all exposed tubers.

(3) Heap up the soil in ridges along the potato rows.

(4) The potatoes as soon as they are dug up should be carried away *at once* to the godowns and never left even for a short time exposed on the field.

(5) Always store the gunny bags in a well ventilated room and turn the potatoes out of these bags at least once a month, when any potatoes which may have become diseased should be removed and the sound one returned to the bags which should at once be tied up. Only open one or two bags at a time in case any worm in one bag should find its way into another bag. A gunny bag holds 120 lbs. and costs only 4 annas and therefore gunny bags to hold the produce of one acre will cost Rs. 120 and these will remain in use for several years.

(6) Never put fresh tubers which have remained exposed in the field in the same bag as the sound potatoes as the worm will come out of the green potatoes and enter the sound ones."

Though the trials with English potatoes have shown crops ranging from 20,000 to 33,000 lbs. per acre on small trial plots, as they were not proof against insect pests and rot, the Department has been wise to postpone their distribution among the surrounding farmers.

That the Indian raiyat can produce a fair crop of potatoes with the means at his disposal there is no doubt. If he knew more about the value of phosphoric acid and potash and the use of concentrated nitrogenous fertilizers, he would probably not endanger the crops by *overdoses of nitrogenous manures that are often the cause of rot* and probably are conducive to ring disease.

It is not the healthy potato that attracts the worm but such as have been grown with the aid of ill-balanced fertilizers.

In Crop Experiments, Bombay Presidency, 1890-91, we find that at Khed (Poona District) on good, deep, black, garden soil, growing during the four preceding years bajri as kharif and potatoes as cold weather crops, an acre irrigated from a well and manured with 22 cartloads of cowdung, etc. produced 10,940 lb. of tubers, of which 6,920 lb. were firsts, 2,800 lb. seconds, and 1,220 lb. thirds, and this was only an eight anna crop ; so that 10 tons of potatoes per acre is not an unknown crop in the country.

The question of manuring is all important in treating of crops in India. Cultivation is well understood, but additions of artificial fertilizers and the replacement of farmyard manure by them is not sufficiently well known.

Now, in all practical farming, experience is generally the most reliable guide, and the successful farmer is one who profits by experience—not only results on the home farm, but the experiments made elsewhere. We all want experience, but life is too short for each farmer to cover all the problems of the soil, and he must use more or less the knowledge gained by others. It is advisable to adapt what others have learnt to your own circumstances. This can only be done by repeated experiments. Such work is useful even if sometimes we do not succeed. The record and observation of what has been done will always be of value. It will be known what has been tried and what has failed, and so need not be tried again; also what has succeeded and may possibly succeed under other circumstances.

The astonishing results obtained by the use of a few hundred weights of artificial fertilizers added to a moderate amount of cattle manure will not be easily believed by natives of India. Fortunately the experimenters and the reporters of these experiments are alike well known people, and some of the names are those of noted scientists in Agriculture. Once the Indian raiyat understands what profits can be obtained from an acre he will certainly take to the new fertilizers. Wherever experiments are undertaken we find the same good results, and there is little to wonder at. Everywhere the unmanured plots are tons below the manured plots in the harvest, and an average of 10 tons cattle dung together with a few cwt. of artificial fertilizers gives a splendid and profitable result.

Referring to Wolff's tables we find that in 1,000 parts of air-dried substance of the plant there are :—

Nitrogen	...	3·4	per cent.
Phosphoric Acid	...	1·6	,, ,,
Potash	...	5·8	,, ,,

and that of the ashes, viz., the mineral portion taken from the soil,

16·6 per cent. is phosphoric acid and
60·0 ,, ,, ,, potash.

The amounts of plant-foods taken from the soil by one acre of potatoes, yielding 200 bushels are :—

Nitrogen	...	36	lbs.
Phosphoric Acid	...	13	,,
Potash	...	60	,,

and Professor Maercker demands for a full crop a manure containing :—

Nitrogen	...	60	lbs.
Phosphoric Acid	...	24	,,
Potash	...	80	,,

The reason why such large quantities are required compared with those taken up by the crop is simple.

All the plant-food is not available for the first crop and much of the nitrogen is lost in drainage. He recommends 5 to 5½ tons of the best farmyard manure supplemented by commercial fertilizers. The experiments have been most carefully carried out, and comparisons made between manures used singly or in incomplete groups, and others that formed a complete fertilizer, and the latter were again tried in varying quantities and proportions, till an almost perfectly complete and well-balanced manure has been obtained. With reference to the price of commercial fertilizers used principally for their potash and phosphoric acid, it must be borne in mind that a fair residue is left in the soil for a subsequent crop, sometimes for two or more. Of various experiments with incomplete fertilizers, those of Dr. Aitkin, recorded in the Highland Society's Transactions of 1887, are decidedly interesting :—

A complete manure gave ...	7 tons	3	cwt.
One without Phosphoric Acid	4 ,,	19	,,
One without Nitrogen ...	4 ,,	9	,,
One without Potash ...	3 ,,	1	,,

Those of M. LeHenry of Ferre are quite telling :—

1.	Unmanured	4 tons	5¾	cwt.
2.	Manured with farmyard manure	5 ,,	0	,,
3.	The above and 480 lbs. Basic Slag	10 ,,	14¼	,,
4.	Manured as in plots 2 & 3 & 80 lbs. Nitrate of Soda	11 ,,	18½	,,
5.	Manured as in plots 2, 3 & 4 & 160 lbs. Sulphate of Potash per acre ...	12 ,,	17	,,

Mr. T. C. Ruwoldt, of Mount Gambia, used 1 cwt. of bone dust as a manure for wheat, and the resulting crop of potatoes sown after, was 6 tons. With 5 cwt. of bone dust the crop was 8 tons.

The following experiment with various fertilizers is worth attention. It was a test plot, that is an even level tract of land was divided into six equal plots, and treated with fertilizers, the cultivation, being the same on all plots.

	Total yield.	Markable tubers.
Plot 1. No Manure ...	17 cwt.	10½ cwt.
,, 2. Ammonia, Potash and Phosphoric Acid	1 ton 6¾ ,,	1 ton 1½ ,,
,, 3. Ammonia and Phosphoric Acid	1 ,, 2 ,,	0 ,, 17½ ,,

Plot 1 shows what the unfertilized soil will produce; plot 3 what nitrogen and phosphoric acid did towards increasing the crop, and plot 2 shows what potash, when added to the fertilizer used on plot 3, and thus completing it, did towards increasing the yield. Without potash the fertilizer increased the crop of marketable potatoes 6¾ cwt., but by adding potash the crop was increased to 12½ cwt. over the yield of the unmanured soil. Without fertilizers only 61 per cent. were marketable, with incomplete fertilizers 80 per cent. were marketable, but, by adding potash, 87 per cent. were marketable, and at the same time the crop was increased.

The season was very unfavourable through drought and the crop a failure, as can be seen from the low yield of potatoes. Upon harvesting, the land was broken and sown to turnips, without additional fertilizer. The following are the results :—

	Total crop.	Marketable turnips.
Plot 1. No Manure ...	1 ton 0¼ cwt.	0 tons 7¾ cwt.
„ 2. Ammonia, Potash and Phosphoric Acid ...	3 „ 9¾ „	3 „ 4 „
„ 3. Ammonia, and Phosphoric Acid.	2 „ 14½ „	2 „ 2¾ „

The unfertilized soil, plot 1, produced but 7¾ cwt. of marketable roots, while plot 3 with an incomplete manure, gave 2 tons 2¾ cwt. By adding potash this was increased to 3 tons 4 cwt. Without a fertilizer, only 37 per cent. were marketable; with an incomplete manure, plot 3, 78 per cent. were marketable; by adding potash 92 per cent. were marketable, and at the same time nearly eight times the marketable crop was made. It must be remembered also that for both crops there was only one application of manure used.

The fertilizer supplied per acre was as follows:— On plot 3 600 lbs. superphosphate and 180 lbs. nitrate of soda. Plot 2 received the same application, and besides 120 lbs. muriate of potash in addition. Note the gain due to the addition of 120 lbs. of *muriate* of potash. This fertilizer is about the same as a commercial fertilizer testing :—

3 per cent. Nitrogen
8 „ „ available phosphoric acid and
6 „ „ Potash.

The Cupar and North of Fife Agricultural Association Society (Limited) had a very interesting competition in the growing of potatoes, the Stassfurt Potash Syndicate having given prizes for the best three acres of potatoes grown with the aid of potash in any form, half an acre to be grown alongside the plot without potash. The Judges—Messrs. John Lawson, Falkland Wood, and John L. Brown, potato merchant, Cupar, issued their report. The prize winners were :—

1st—Alexander Orchison, Torr of Moonzie.

Tons.	Cwt.	Qrs.		
15	7	1	Maincrop,	ware.
	17	3	,,	seconds.
	11	3		refuse.
16	16	3		

2nd—William Watt, Middlefield, Cupar.

Tons.	Cwt.	Qrs.		
14	7	1	Up-to-date	ware.
	18	2	,,	seconds.
	15	1	,,	refuse.
16	1	0		

3rd Prize.— 4. 4. Edie. Cornceres.

Tons.	Cwt.	Qrs.		
14	16	2	Good Hope	ware.
	12	1	,, ,,	seconds.
	6	0	,, ,,	refuse.
15	14	3		

4th Prize.—D. M. Kerracher, Mayfield, Ceres.

	Tons.	Cwt.	Qrs.		
	12	4	0	Glorys,	ware.
	1	10	3	,,	seconds.
	1	1	2	,,	refuse.
Total.	14	16			

The judges add the following report:—"In valuing crops we value maincrops 10 sh. per ton more than other kinds. All over the experiment has been a great success. On examining the various crops put forward for competition we found that those crops where potash had been applied showed a great improvement in quality and quantity in contrast with the crops where this agency was not applied. Nevertheless, the increase varied a great deal. For instance the highest and lowest increases were 52 per cent. and 8 per cent. respectively. The average increase all over was 16 per cent. In those crops where potash was not applied, second growth was very evident, and seed was more plentiful than the crops on which the potash was applied. In some cases on high conditioned land, the increase was not striking, but on less conditioned land the increase of marketable potatoes was especially noticeable. The good results accruing from the application of potash more than compensates for any outlays.

Result obtained in 1903 on Sandy Loam, in fair condition by James M. Scott, Esq., Crookes, Newent, Gloucestershire:—

Manure applied per acre.	Weight of Potatoes per acre.
6 Cwt. Basic Slag Farmyard Manure 1½ Cwt. Sulphate of Potash . 1½ Cwt. Nitrate of Soda .	5 tons.
Farmyard Manure 1½ Cwt. Sulphate of Potash ... 1½ Cwt. Nitrate of Soda .	4 tons.
Increase due to the complete manure ...	1 ton per acre.

Value of increase at 70*s.* per ton...	£3 10*s.* 0*d.*	per acre.
Cost of 6 cwt. Basic Slag (30—35 per cent). ...	£0 15*s.* 0*d.*	„ „
Profit by completing the manure...	£2 10*s.* 0*d.*	„ „

Basic Slag applied on 14th April. Potatoes dug middle of August.

Result obtained in 1903, on rather Light Sandy Soil in good condition, by David Hulme, Esqr.—Hulme, Walfield Hall, Cogleton, Cheshire.

Manures applied per acre.	Weight of Potatoes per acre.
6 Cwt. Basic Slag ... 5 Cwt. Kainit ... 1½ Cwt. Nitrate of Soda ...	9 tons 17 cwt. 56 lbs.
5 Cwt. of Kainit ... 1¼ Cwt. Nitrate of Soda ...	8 tons 2 cwt. 96 lbs.
Increase due to Basic Slag ...	1 ton 14 cwt. 72 lbs.
Value of increase at 53*s.* 4*d.* per ton ...	£4 12*s.* 5*d.* per acre.
Price of Basic Slag ...	£0 15*s.* 0*d.* per acre.
Profit due to Basic Slag or rather to complete manuring	£3 17*s.* 5*d.* per acre.

Basic Slag applied on 25th April, Potatoes dug on 20th October.

In 1902 Mr. E. B. Pennington, of Kennedyville Maryland, made an experiment in fertilizing potatoes. His soil is a fair sandy loam, with red clay sub-soil. He selected a portion of the field which was uniform in productiveness, and divided it into three plots of one-third of an acre each. Plot 1 received no fertilizer, plot 2 received, per acre, 120 lbs. sulphate of potash, 100 lbs. superphosphate and 180 lbs. nitrate of soda. Plot 3 received the same amount of superphosphate and Nitrate of Soda as plot 2 but no potash.

Plot	1.	No manure	1 ton 2 cwt.
,,	2.	Complete manure	3 ,, 17½ ,,
,,	3.	Incomplete manure without potash	3 ,, 3⅓ ,,

One ton 2 cwt. was the yield of the soil not manured, and therefore the gain from fertilizers is as follows :—

	Tons	cwt.
Fertilized without Potash	2	1½
Fertilized with ,,	2	15⅓

The complete fertilizer produced 14¼ cwt. of potatoes extra. Mr. Pennington reports that the potatoes on fertilized plots were markedly of better quality than those of the unmanured plot. The manure used was not excessive. Many of the most successful growers on Long Island, New York, use a ton and over per acre.

From the results it is clear that the profit made was due to the manures, and the greatest profit was from plot 2, with 120 lbs. of Sulphate of Potash in a complete manure.

Professor Schneidewind of Halle in his " Potash manuring on good soils", writing of the needs of the Potato says ; " Of all cultivated plants the potato stands most in need of potash. As a typical potash plant it requires great quantities of this manure, yet assimilates the potash of the soil worse even than the turnip." Potatoes are often raised with mineral fertilizers, with green manures after red clover and lucerne stubble, and with cattle manure. Should the cattle manure not be abundant and if it be poor in potash, enough potash will not be placed in the soil to produce the highest return. Most interesting experiments were carried out by Schneidewind at Lauchstadt since 1899. On the one hand cattle manure was always used as the fertilizer, on another plot farmyard manure was never used. On these plots potash manuring was tried every year, so that its action with stable manure and without it could be determined. From the plots on which potatoes were cultivated from 1899-1903 without farmyard manure, better results were obtained: on an average 7·72 tons tubers and 1·274 tons starch. This increase was obtained by the use of 6 cwt. of 40 per cent. potash salts, or similar quantities of potash in the form of kainit. Deducting the expenditure on potash, viz. Rs. 6, a net extra profit remained, per acre, of Rs. 49. We see from this that it would be a great mistake were we not to add potash to the soils where potatoes are grown without potash manure. The potato requires very large quantities of potash for its nourishment, which even good soil, rich in potash, cannot place at its disposal. On good soils potatoes are often treated with green manures, and the question arises whether it is necessary in this case to use the Stassfurt potash salts.

With the addition of potash, as we have seen in the experiments noted above, the potato harvest was increased to an extraordinary degree, showing the great advantage gained by the addition of potash to the green manure. Especially where cattle manure is not in abundance, the effect of manuring with potash is patent, when added to the green manure ploughed in. But besides the potash, in cases of green manuring, the land requires an addition of phosphoric acid and of some nitrogen. You can distinguish potatoes grown where not much potash was placed at their disposal, by the very dark, nearly bottle green leaves, that are at the same time smaller than those of plants well supplied with potash. Potatoes treated with plenty of potash and a sufficiency of nitrogen were noted for the light green colour of their leaves and their larger size. To increase the amount of potash available for plant-food by larger amounts of farmyard manure is to waste the costly nitrogen contained in it by adding to the soil more than the potato harvest requires. A little stable manure can be added to the green manuring but very much is never advisable. We learn also from these experiments that when cattle manure is used that is not rich in food stuffs, and especially dung from which the urine has drained away, potash salts can be used with excellent results, even on good soils containing a fair amount of potash as shown by analysis. Potash will not be necessary as an addition to the manure if 16 to 20 tons of good cattle manure are used, in which the urine has been retained; but with poorer dung, containing plenty of straw and little of the urine of cattle, it is always advisable to add potash salts.

The quantity of artificial manures used upon potatoes in Scotland often runs to 15 and 18 cwt. per acre.

In the report of the Department of Land Records and Agriculture, Assam, for the year ending 30th June, 1905, mustard cake at the rate of 20 maunds per acre, produced a crop of 213 maunds, 13 seers.

From the Report of the Cawnpore Farm, and other Experiment Stations in the United Provinces, for the year ending June 30th, 1903, we find the heaviest average of the crops of seven years amounting to

6 tons, 0 cwt., 2 qrs., 20 lbs.

from the use of cowdung at 200 lbs., nitrogen per acre, which is equivalent at Dr. Leather's analysis of 0·3 per cent. of nitrogen to about 29½ tons of cowdung, an amount of manure absolutely unattainable by the majority of farmers. Here we see what has been established in most potato growing countries that stable manure in large quantities does not give near such good results as a much smaller quantity of well-rotted farmyard manure to which is added a small quantity of artificial fertilizers supplying the necessary phosphoric acid and potash in a form which places the plant-food immediately at the disposition of the tubers.

Again on the same Farm the use of about 4 tons of castor cake per acre returned a remarkably poor harvest, during 7 years, showing only too clearly the necessity of employing a complete fertilizer.

Wilfarth showed that when the supply of nitrogen is insufficient the leaves tend to turn yellow, and that if the available supply of potash is deficient heavy applications of nitrogen tend to reduce the percentage of tubers and starch. Lawes and Gilbert show that nitrogen stimulates the production of starch, provided the mineral constituents are not deficient; but *in large quantities nitrogenous fertilizers stimulated luxuriant growth, delayed maturation, and produced potatoes richer in nitrogen and much more liable to disease,* a point that should be remembered in all experiments.

At the Rhode Island Experiment Station dried blood ranked first of the nitrogenous fertilizers applied, followed by nitrate of soda and sulphate of ammonia; but on soils said to be extremely acrid, dried blood was only about half as beneficial as it should be; hence such soils need liming before full benefit can be derived from the use of this fertilizer. A mixture of two-thirds dried blood and one-third nitrate of soda, or of equal parts of all three fertilizers, is suggested. At the Tennessee Experiment Station cottonseed-meal was found to be a more profitable source of nitrogen than nitrate of soda, while at the Florida Station the nitrogen of cottonseed-meal and castor poonac were equally effective, but that of nitrate of soda was more so by 30 per cent.

Wilfarth and Wimmer show that, when potassic fertilizers are applied to soils almost destitute in Potash, they

1. Increase the size of the tuber, but have little influence upon its composition, and that the amount of potash in tubers remains fairly constant, uninfluenced by the amounts in the soil or applied, unless very heavy applications are made, which may cause an increase to a certain point, but will be attended by a decline if continued.

2. Decrease the precentage of stems and leaves, but have no marked influence on the roots of potatoes.

3. Have a marked influence on the shape and apearance of the leaf; if deficient, the leaves are yellowish-brown in colour, and become spotted and striped in the portions between the veins, while the petiole of the leaf and the ribs retain their dark green colour. If the supply of potash is insufficient the leaves tend to curl, and sometimes collapse of the plant follows.

4. Increase the quantity of water transpired per gramme of dry matter.

Hecke shows that the application of potassic fertilizers has a marked influence in the production of tubers and roots, and that potash assists in the formation of starch. Lawes and Gilbert noted that the percentage of potash was relatively high when the supply of it was relatively liberal and vice versa, but the variations were small, and that, where there was a deficiency of potash in the supply and in the ash, there was generally an increased supply of lime in the ash.

Dr. J. J. Willis in his " Value of Potash to Farmers " as indicated by the Rothamsted Experiments, writes :—

" In the case of the potato the carbohydrate produced is starch. Potato tubers are reckoned to contain, on an average, more than 20 per cent. of starch, and upon the amount of starch in the potato depends its nutritive value and cooking properties for domestic use.

The following table shows the result obtained at Rothamsted with potatoes when grown without manure and with various artificial fertilizers. The figures quoted are the results of the average for ten years in succession on the same land, 1876-1885.

Experiments with potatoes at Rothamsted. Amount of starch in the tubers per acre.

Plots.		Starch per acre. lbs.	Increase over the Un-manured. lbs.
1. Without Manure	...	1,120	...
2. Phosphate of Potash	...	1,988	868
3. Ammonia Salts alone	...	1,169	49
4. Nitrate of Soda alone	...	1,362	242

Plots.	Starch per acre. lbs.	Increase over the Unmanured. lbs.
5. Ammonia Salts with Phosphate and Potash ...	3,436	2,316
6 Nitrate of Soda with Phosphate and Potash ...	3,368	2,248

It seems that the quantity of starch in the potato tubers is considerably increased by the application of Phosphate of Potash, amounting on plot 2, to 868 lbs. per acre. The increased amount of starch over that without manure, obtained by nitrogenous manure alone, is very small—only 49 lbs., when as Ammonia Salts on plot 3, and 242 lbs. per acre when as Nitrate of Soda on plot 4. But when Nitrogen, Phosphate and Potash are employed together, the increased amount of starch produced is more than one ton per acre—2,316 lb. on plot 5, with Ammonia Salts, and 2,248 lbs. with Nitrate of Soda. When Phosphates and Potash are added to the Ammonia Salts, or Nitrate of Soda, there is for one of Nitrogen supplied in manure, over 26 parts increased produce of starch reckoned over the yield of tubers without manure.

Here, then, in the Potato, we have a great increase in the production of the carbohydrate starch, by the use of Potash in manure, just as in the mangel crop we have a considerable increase of the carbohydrate sugar, by the use of Potash Salts.

As, thus, the root crops are essentially sugar yielding crops and their feeding value depends upon the proportion of this constituent, so the potato is essentially a starch-yielding crop, and its cooking and feeding value depend to a very large extent upon the percentage in the tubers. And it is seen that, provided a liberal supply of potash is available in the soil, the produce of both sugar and starch is considerably increased by the amount of Nitrogen taken up, the ingredient Potash, acting as a carrier of Nitric Acid from the soil to the plant.

Which is the better source of Potash?

Sulphate or Muriate of Potash?

This question is still unsettled, because apart from other considerations, one of the deciding factors is the cost of each. In many cases the results are inconclusive, while in some cases the fertilizers appear to be of equal value. In others Sulphate of Potash gave better results; thus Davidson of Virginia, found that the potatoes grown by Sulphate of Potash contained more dry matter but a less percentage of starch than those fertilized by Muriate of Potash. Brookes found that Sulphate of Potash gave a better yield per acre of merchantable tubers, which were of larger size and superior eating quality, containing from 2 to 3 per cent. more starch, and, when cooked the potatoes were whiter, of better flavour, and more mealy.

The disadvantage of Muriate of Potash seems to be due to the fact that it is a chloride, and Sjollema and Pfeiffer have shown that the chlorides of Potassium, Sodium (Common Salt) and Magnesium, when added to the Sulphate of Potash, diminished the starch content of the potatoes considerably, and the reduction was greatest in varieties rich in starch. This would seem to support the common idea that Sulphate of Potash produces a better quality of potatoes than Muriate of Potash. Wheeler of Rhode Island, shows that Calcium Chloride, had a marked poisonous effect on potatoes and nearly destroyed them, while the same amount of Calcium in certain forms other than the chloride or sulphate, increased the yield and vigour of the plants. New varieties, and those making a heavy growth of haulm, seem to be particularly sensitive to chlorides.

Yet the German Agricultural Society, judging from their experiments with potatoes consider kainit, which contains a great deal of common salt, as the best potassic fertilizer for potatoes.

Influence of Phosphoric Acid.

Lack of Phosphoric Acid is accompanied by dark green leaves. While Phosphoric Acid aids starch formation, it is often regarded as of less importance than Potash. The results obtained at the Ohio Station show that Phosphoric Acid is the most essential fertilizer for their conditions, some Potash, and, in some cases, Nitrogen being also required. The same was true at Briarcliff Manor, New York, where 100 lbs. available Phosphoric Acid per acre equal to 600 lbs. Acid Phosphate, 16 to 17 per cent available, gave profitable returns. An excessive application of available Phosphoric Acid has a marked effect upon the foliage causing it to be small, dark, wrinkled, green and apparently stunted in development with consequently early maturity. In some cases the period of growth is reduced six or eight weeks, and consequently the yield is low, but owing to the potatoes being mature, the quality is generally good. In certain localities, for early potatoes, where it desirable to hasten maturity, the use of fair quantities of Superphosphates, with a limited supply of Potash and Nitrogen and no barn manure, is found to be good practice. The Nitrogen may be supplied in an available form as Nitrate of Soda, since nitrification may not be active in the soil during the early period of growth.

Early potatoes require the quickest possible acting manure as the time from sowing to maturing is short. Peruguano is better than dung in this case for the latter is slow in decomposing and placing the food at the disposition of the tubers. But while the beet prefers Saltpetre the potato thrives better on Sulphate of Ammonia

For late potatoes manuring with dung is good practice. In cases where, owing to an insufficiency of lime, there is nothing to neutralise sufficiently iron combinations in the soil, marling is necessary to avoid the brown patches that show a want of starch within the potato.

Influence of Calcium.

Calcium does not appear to be so important, although in some cases it produces a marked increase in yield. If applied in a form that has an alkaline action upon the soil—as, Carbonate of Lime, or quicklime, it may have an injurious effect by producing conditions which aid the development of scab.

Barn or Farmyard Manures.

Applying Barn or Farmyard Manures is commonly practiced for potatoes with profitable results. Lawes and Gilbert showed that only a small portion of the nitrogen of farmyard manures is taken up by the crops ; thus, with an annual manuring of 15½ tons per acre, containing 200 lbs. nitrogen, continued for 12 years, but 8·3 per cent. was recovered in the crop. "These results seem to indicate that this crop is able to avail itself of a less proportion of the nitrogen of the manure than any other farm crop. Yet, in ordinary practice, farmyard manure is not only largely relied upon for potatoes, but is often applied in larger quantities than for any other crop."

Taft of Mchigan, found that twenty-four loads of manure per acre gave the largest yield, while at the Winconsin Experimental Station twenty loads per acre were applied, and larger quantities in Great Britain.

It seems natural to assume that the beneficial effects of manure must largely be due to other causes than the addition of plant-food only. Among these may be its influence on the physical properties of the soil, rendering it more retentive of moisture, more porous and more permeable for air and roots, and a better home for the useful soil bacteria, which, in fact, it may supply. The decomposition of such quantities of organic matter, with the consequent liberation of carbon dioxide, aids in rendering the mineral resources of the soil more available. Generally speaking, it is more economical to apply about ten tons of manure per acre and supplement it with fertilizers, except upon loose, open soils of poor texture where the beneficial effect from the larger amount should probably be ascribed to its influence upon the retention of moisture. It is preferable that the manure be rotted somewhat and applied some time before, while the fertilizers may be applied when planting. On some soils, to reduce the danger of disease, it may be advisable to apply all the farmyard manure to the previous crop.

The application of fertilizers is profitable under most conditions in the Eastern and North Central States of the United States of America.

In long Island a mixture containing :—

4 per cent. Nitrogen
8 ,, ,, available Phosphoric Acid and
10 ,, ,, Potash,

has proved satisfactory. It is used in amounts varying from 500 lbs. to 2,000 lbs. per acre, and in many cases more potash is applied than is profitable. The use of

1,000 lbs. of this fertilizer has given the greatest profit. Where 1,500 lbs. or 2,000 lbs. were used the cost of the fertilizer was more than the market value of the increased yield of potatoes. The fertilizers should be complete without being wasteful in quantity.

100 lbs. Sulphate of Ammonia
100 ,, Superphosphate (16 to 17 per cent. available)
and 200 ,, Sulphate of Potash, with
8 to 10 tons of partially rotted farmyard manure per acre, will be found a well-balanced complete manure and the resulting crop will pay well.

The results obtained in a very carefully conducted experiment in the manuring of potatoes are illustrated, and the well recognised value of a complete commercial manure for the potato crop is clearly demonstrated, as is also the great loss resulting from the omission of the most essential constituent, viz., Potash, from such a manure, by Mr. Holmes, of Saltwarpe, Droitwick, Worcester, England, in 1902.

Where no manure was used the crop amounted to only 4 tons 2 cwt. per acre, and where the complete manure consisting of 1 cwt. of Sulphate of Potash, 2 cwt. Nitrate of Soda, and 4 cwt. of Basic Slag was used, the yield was 12 tons 6½ cwt.

In the absence of farmyard manure, it can with advantage be wholly replaced by artificial manures, 2 cwt. of Basic Slag per acre is recommended, and, in addition, Potash 2 cwt. and Nitrogenous manures, such as Saltpetre, 4 cwt. according to the nature and condition of the soil.

The following results on potatoes, obtained in 1899 on gravelly loam, by Mr. Rouse Orlebat, at Poddington, Bedfordshire, show, (*a*) The effects of an incomplete fertilizer without farmyard manure.

(*b*) The results from a complete artificial fertilizer also without farmyard manure.

No. of plot.	Manuring per acre.	Cost of Manuring.	Weight of crop per acre.	Increase over unmanured plot per acre.	Value of increase per acre.	Profit obtained by Manuring.
		£ s. d.	Tons. C.	Tons. C.	£ s. d.	£ s. d.
1	No Manure ..	..	8 4½	..	..	..
2	Muriate of Potash 1½ cwt. Nitrate Soda 1½ cwt ..	1-10-0	10 18½	2 14½	7-9-3	5-19-3
3	5 cwt. Basic Slag 1½ ,, Muriate of Potash 1½ cwt. Nitrate of Soda ..	2-2-6	12 8½	4 4½	11-11-6	9-9-6

A comparison of the yield and profit of plot 2 (to which no phosphoric manure was applied) with the yield and profit of plot 3 (which received 5 cwt. of Basic Slag per acre) shows that the phosphoric acid in the complete manure effected an increase of 1½ tons of potatoes and a profit of £3 19s. 3d. per acre.

This is confirmed by the Report from Georgia State Station, Bulletin No. 8, July, 1890 :—

"The results seem to warrant the conclusion that a fertilizer containing all the food elements in the same proportion and in available form, as a good stable manure, gives the largest increase, and that incomplete fertilizers, while they show a gain over the unfertilized plots, are not remunerative. A quick-growing crop like the patato, which has only a short time in which to mature, cannot be grown sucessfully unless a bountiful supply of all the elements of plant-food is provided; that is, the greatest yield is obtained where the soil contains an excess of all the elements of plant-food in available form over and above the requirements of the plant."

Professor Wright in his report on the Manuring of Potatoes, in 1889, says :—" Ten tons farmyard manure with suitable commercials are better than more farmyard manure alone."

On trial plots in poor gravelly soil in the North Arcot District (Madras) where potatoes, as a rule, are not grown, a very successful crop has been cultivated with

10 tons cattle manure
5 cwt. ground nut or castor cake
1 cwt. bone meal and
1½ cwt. Muriate of Potash.

Thus we see that a small expenditure on complete artificial or commercial manures invariably brings a good return for potatoes, and helps, to a considerable degree, the succeeding crops. Little more need be said in favour of these fertilizers, new to India. Indian farmers, who are wise enough to profit by the experience of others, will make experiments on a small scale, and, when successful, increase their income considerably by adding the newest experience of the West to the old-world traditions of the East.

It is astonishing how small the acreage is under this crop in India when we compare the feeding power of the potato with that of wheat and barley. The average out-turn of potatoes is about 50 maunds per bigha. With an allowance of one seer per adult per day (supplemented with a handful of rice) a bigha is capable of supplying food for 2,000 adults per day. The average yield of wheat or barley is about 5 maunds or 200 seers of grain. Allowing the same quantity per day per adult, a bigha of barley will therefore yield food for 200 adults or one-tenth of that produced by the potato.

The probable cause is the danger of blight and rot, and the difficulty of keeping seed over for the next sowing season. But this should not be insuperable. Careful cultivation with the best manures and fertilizers available ought to prevent much of this and lead to the covering of a great deal more of garden land with this excellent paying crop.

What an ordinary crop of potatoes ought to be is shown in "Crop Experiments"—1888-89, page 12, where Mr. Lucas the Assistant Collector, Poona, writes:—"Potato is an important staple of the Khed Taluka, the area under the crop being 7,000 acres this year. The produce is all sent to the Poona market for sale. According to the Taluks formulas, the rate of seed is 1,000 lbs. per acre, and the 14 anna crop is estimated to yield 16,800 lbs. or an out-turn equal to 16-fold of the seed sown.

In the Poona Farm Report, 1884, page 19, we find:—"The potatoes imported during the year were grown with the assistance of artificial manure only, with the result that the produce was absolutely free from disease." Here, very probably, there was not an excess of costly nitrogen, so common on Government Farms, where an immense amount of cattle manure is at the disposal of the Superintendent, and only confirms the statement that an over-supply of farmyard manure is hurtful. It is confirmed by the experiments on the Dharwar Farm in 1908-09 in the trial with fresh Italian potatoes where a harvest of 13,000 lbs. of tubers was obtained, valued at Rs. 474, and on another plot the return was Rs. 545.

Annual Report of the Experimental Work of the Dharwar Agricultural Station, 1908-1909 :—

Potatoes. Potatoes at Belgaum.

With the object of ascertaining whether artificial fertilizers can be economically used as a supplement to, or a substitute for, farmyard manure the following experiment was conducted :—

CROP.	MANURE. Kind.	MANURE. Quantity per acre.	Seed Rate per acre	Yield per acre.	Cost of Manure.	Value of Outturn.
			in lbs.	in lbs.	Rs. A. P.	Rs. A. P.
Fresh Italian.	Farmyard ..	10 tons	1,863	13,309	25 0 0	175 5 1
Fresh Italian	Farmyard plus Ammonium .. Sulphate .. Superphosphate .. Sulphate of Potash ..	10 tons 1 cwt. 2 cwt. 1 cwt.	1,821	13,276	53 14 9	474 2 0
Fresh Italian.	Ammonium Sulphate .. Superphosphate .. Sulphate of potash ..	2 cwt. 4 cwt. 2 cwt.	2,136	15,264	27 13 6	545 2 0

The land was rich in humus having been cultivated for the potato crop for several years.

This experiment is on the right lines and can be compared with the following manurial experiment made :—

Sandy Loam......Poor Soil.

Manures per acre in lbs.					Harvest per acre bushels.		
Plot.	Gypsum	Chili Saltpetre	Super-phosphate.	Sulphate Potash.	Large.	Small.	Total.
1. Unmanured ..	..	..	..	..	90	55	145
2. ..	..	158	440	..	100	63	163
3. ..	158	..	..	..	86	53	139
4. ..	..	158	..	158	231	43	274
5. ..	..	..	440	158	248	45	293
6. ..	..	158	440	158	278	71	349

We have this further proved in the latest issue of the Agricultural Gazette of New South Wales on February 1911.

Potatoes at Crafton Experiment Farm.—This last season some excellent results were obtained at Crafton Experiment Farm with potatoes grown partly to test the comparative value of certain classes of manures and partly as a commercial crop. From an area of 6½ acres 614 bags were harvested, the total weight of potatoes being 50 tons 3 cwt. Of these 534 bags were sold, the prices obtained ranging from £8 10s. to £11 10s. per ton and totalling £422 18s. 10d. net cash. The value of 20 bags kept for seed may be taken as £13, and 10 bags of small potatoes left are worth £1 10s. This gives a total return of £437 18s. 10d. and the actual profits allowing for rent, work out at just about £50 per acre.

The variety grown was Adirondack, and the seed was obtained from Mr. J. E. Bennet, near Bombala.

Portion of the area was covered by 54 plots each 1/40 acre in extent, devoted to the testing of various combinations of fertilizers. This area, 1 17/20 acres, returned 15 tons 13 cwt. 20 lbs. of potatoes or 11 tons 14 cwt. 105 lb. per acre. The soil is rich in alluvial scrub land—some of the best on the farm—of good depth, and possessing fair natural drainage. The manures were mixed with a little more than their own bulk of dry sand to ensure as even a distribution as possible and sown broad cast some days in advance of planting. The potatoes were ploughed in. Of these 54 little plots the highest yield was obtained from that which received a dressing of 240 lb. dried blood, 300 lb. bonedust, and 132 lb. chloride of potash per acre. This plot gave 7 cwt. 51 lb. of potatoes, or 14 tons 18 cwt. 24 lb. per acre. Another plot, dressed with bonedust alone, at the rate of 2 cwt. per acre. gave 14 tons 8 cwt. 104 lb. per acre. Other combinations which gave excellent results were :—

½ cwt. Sulphate of Ammonia, and 2 cwt. superphosphate.

1 cwt. Sulphate of Ammonia, and 4 cwt. bonedust.

½ cwt. Sulphate of Ammonia, 2 cwt. superphosphate and ½ cwt. sulphate of potash.

240 lb. dried blood, 300 lb. superphospate and 132 lb. chloride of potash.

½ cwt. Nitrate of Soda, ½ cwt. Chloride of Potash.

½ cwt. Sulphate of Ammonia and 2 cwt. bonedust.

All of these yielded over 13 tons per acre. The results are not regarded by the department as decisive as to the value of any particular manure or combination, but they certainly show the advantage of using fertilizers for potatoes even on rich soils"

According to Dr. Claussen, it is not merely the value of the plant food that requires consideration: his experiments tend to prove the tonic properties of such fertilizers as superphosphate and basic slag, which accelerate sprouting, push on the growth of the young plants, strengthen them during the course of their life, increase the harvest and hasten maturity.

It is painful to find that it has taken so great a length of time for the Department of Agriculture to begin with experiments long carried on in other countries and proved excellent.

There is not much use in spending years to endeavour to stop rot if the old method of manurig,most probably one of the contributory causes, is continued.

It is so simple to see what has been done in the shape of manuring by other countries, and to follow that as a starting point Having learnt that complete manures are most successful in obtaining bumper crops that will keep, variations may be tried in the constituents of a complete fertilizer, till experience shows the best balanced and cheapest manure, which will return the most paying crop.

In conclusion we should like to hear from Indian farmers what they have to say concerning the "Lunar Superstition and Potatoes" whilst giving the decision of the United States Department of Agriculture on the subject. Enquiries about the so-called Lunar Superstition and Bamboos proved the Native correct as to the time for cutting these and the 'Superstition' resolved itself into 'experience' of fact for which the farmers (and Agricultural Scientists) had no ready explanation.

Lunar Superstitions.

"After exhaustive experiments in Potato planting, the United States Department of Agriculture has to say that, in season, one time is as good as another to put potatoes in the ground.

Almost everyone, even if he were not reared in the country, has heard of the idea about planting potatoes in the dark of the moon. The field workers of the Department of Agriculture have been investigating the matter, and have found that seventy-five per cent. of the farmers of this alleged enlightened country put in their crops and do a good many other things about the farm, governed solely by the moon's phases. Many farmers will tell you that if you plant potatoes in the dark of the moon they will run to tubers, and if in the light of the moon they will run to tops, and crops are planted accordingly.

There is usually a basis in fact for any superstition so deeply rooted, and a number of experts from the Department of Agriculture, while going up and down and across the land, have made it their business to study the question and see whether there might not be a germ of truth, or, at least, some reason for the general belief that the moon's phases have an effect on animal and vegetable life. They have concluded after patient investigation that the moon myth is one of the comparatively few myths that date back to pure savagery, and has not an atom of scientific foundation on which to stand. The Agricultural Experiment Stations all over the country have been defying the superstition for several years and raising just as good crops when the moon was one way as when it was the other. Therefore, once and for all, it has been conclusively decided that there is nothing in the theory that potatoes should be planted in the dark of the moon.

All this might not seem very serious investigation for a great Government to undertake, but the work nevertheless has been interesting to scientists, and if they have succeeded in weaning a few from the old superstition about planting potatoes in the dark of the moon, they have been well paid for their work."

ONIONS.

To the question on what soils onions may be grown, the reply is that any soil will do ; but a rich sandy loam is by far the best. This should be kept as free as possible from weeds and manured with well-rotted cowdung. Care must be taken, however, that onions are not planted shortly after a heavy manuring with farmyard manure that is not well rotted, or onion maggot may do heavy damage to the crop. The land must be ploughed early to allow of a thorough aëration of the soil and the cultivation must be thorough, if a bumper crop is expected. The previous crop should, if possible, be one that frees the land from weeds.

When there is not a sufficiency of cattle manure, or the manure is not well rotted, and especially where weeds lessen the out-turn considerably, it is wise to lessen the farmyard manure and replace the amount wanting by commercial fertilizers.

Where a large trade is carried on in onions, cultivators find it best to sow the seed in beds and plant them out later in the field, as the onion can be transplanted as easily as garden plants. The better seedlings can be chosen with every promise of a better crop, and as weeding will not cause much expense, the onions are raised at a cheaper rate. This has been found by practical experience, especially in America. A weeding hoe costing from Rs. 12 to Rs. 30 will be found of great use, as its knives run on each side of the row and clean out all the weeds except those directly in the row with the onions.

The various Government and Demonstration Farms have endeavoured to grow onions as an object lesson to the Indian raiyat. In the Annual Report from Lyallpur for 1902-3, the land was manured with 20 cart-loads of house sweepings per acre. On what basis the quality and the quantity were fixed we cannot ascertain, nor what conclusion was arrived at from the experiment, nor can we determine what advantage was to be gained in the trial of the two varieties, as the produce reached the figures of only 7,616 and 7,872 lbs. respectively per acre. At the Manjri Farm near Poona, a good crop was obtained: but as the fertilizer used was 1,116,750 gallons of effluent from a septic tank, between 20th October 1902 and 1st April 1903, what the peasant could learn from the experiment, except that the crop amounted to 31,607 lbs. must be left to the imagination.

Two very interesting experiments are to be found in the Annual Report of the Surat farms, for the years 1901 to 1903. The first states that 34 gunthas manured with 400 lbs. of safflower cake produced 36,285 lbs. of onions worth Rs. 302-6-0, when prices were very low. How the land had been manured for the previous crop of white gourds is not stated. Nor do we know the nature of the soil, but if it represented the average garden of the district, there is no doubt that the return was magnificent, for the very slight fertilizing allowed. In such a case it certainly was an object lesson to the farmer well worth following, and, in any case, it points the right direction in not using cattle manure for the onion crop itself, but from one raised previously, and in adding a certain amount of artificials just before the seedlings are transplanted.

The other experiment was made with two indigenous and two English varieties. We have no record of the manures used or of the time of application. The harvests are far from big, but the statement shows that the indigenous crops were better than the exotics.

	Un-manured	Castor	Farmyard	Poudrette
Surat Red	12343	13543	13371	15828
Thana White	15200	16286	13429	17600
Yellow Globe English	....	....	12571	13714
White " "	....	....	9714	12857

We learn again the great value of a small amount of a concentrated fertilizer like castor cake, which in one case quite equalled the return from farmyard manure and greatly surpassed it in another. An important lesson is also learnt as to the use which can be made of waste products from Municipalities. If ever we find the definiation of dirt verified, we have it in this case, for human excreta must be pronounced a very good thing in the right place and a source of profit, while the health of whole cities is endangered by ill-managed Municipalities which do not use means to prevent its accumulation in wrong places.

The use of human excreta for edible plants also opens out a question worth enquiry. Jæger says "Plants thrive best on the excreta of the animals that live upon them." It would repay careful experiments on various food crops.

According to the Dharwar Farm Report for the year 1906-7 "the oinion crop, though very hardy as an irrigated crop, is a very delicate crop when grown without irrigation." Still an attempt was made to grow onions in the Kharif season, and the yield per acre was (with a mixed crop) 5,240 lbs. of onions and 100 lbs of coriander, valued at Rs. 96-6-10, against an expenditure under cost of cultivation of Rs. 15-12-5.

The experiment is worth continuing, though it is more than probable, the risks are known to the cultivator, which explains why he prefers to treat it as an irrigated crop in the rabi season, as is the case also in the Deccan and in Guzerat.

That the Indian raiyat can grow as good a crop as any Government Farm can produce is pretty clear from the "Crop Experiments—Bombay Presidency." In 1894-5 in Khed (Chancan), Red Onions, (Khandi) were raised from 8. 9 seers of seed, on a mixed black soil field growing ordinarily bajri and onions in one year, followed by ground nuts in the second. Ground nut was grown first. It failed owing to heavy rain, and bajri was substituted for it, which also was a failure. The last crop was dressed with about 17 carts per acre of ordinary manure and watered nine times from a well in the field. Abont 4 Guntha seed beds furnished seedlings for an acre of field. A sample kept by the experimenter lost 11 per cent in dryage in 18 days. This is allowed for in the reported out-turn. Season good and cultivation excellent. Crop 35,022 lbs."

On similar land, which grew during the last three years, (1) ground nut (2) sugarcane (3) bajri followed by onions, the crop was 34,514 lbs. The field had been manured with about 14 carts per acre of farmyard manure, and watered three times a month from a well and also by channel from a bunded stream, which failed in the hot weather. In these cases we have rich garden land, well manured, well tilled, and well watered. On lighter soil where bajri and onions followed ground nut the produce was only 19,228 lbs. though the crop was manured wifh 23 carts per acre of ordinary manure, and irrigated four times a month.

With all the farmyard manure obtainable gathered for raising garden crops, it is easily intelligible that next to nothing remains for dry crops. Yet, with a careful attention to the needs of various plants and the use of oil cakes and commercial fertilizers, much of the valuable dung might be spared for the Kharif crops. It will require some years of careful demonstration, however, before this very necessary reform is introduced.

In the report for 1903, on the results of the sewage farm, it is stated that a crop of 29,726 lbs. of onions removes from the soil.

59 lbs. Nitrogen, 30 lbs. Phos. Acid, 118 lb. Potash. To obtain this, the sewage farm supplied enough potash, more than six times the quantity of phosphoric acid, and seven times the requisite amount of nitrogen.

This does not appear quite in accordance with the dictates of modern scientific intensive farming. As this is one of the best paying garden crops, it is advisable to raise it with the greatest care and without any unnecessary waste.

From the analysis of a good crop it is evident that the harvest deprives the soil of a heavy amount of potash and it must be our aim to place on the field something beyond the amount of potash taken up by the crop if we do not wish to deplete the land. All may not be rendered available for the first year, which is all the greater reason for increasing the supply, the more so, as a great amount of what is not taken up in the crop is retained by the soil. Though the phosphoric acid requirement is small, it is astonishing how much more of this plant food ingredient is annually supplied by al good growers.

The analysis given by the Department of Agriculture in India appears to exclude the leaves. and therefore, to be out considerably in the statement as to the amount of plant foods removed from the soil. From Dr. E. Wolff's tables, we find the common onion contains in every 1,000 lbs. of air-dried substance :—

2·7 lbs. of Nitrogen, 1·3 lb. Phosphoric acid, 2·5 lbs. of Potash and that 30,000 lbs. of onions remove from an acre 81 lbs. Nitrogen, 41 lbs. Phosphoric Acid, and 81 lbs. Potash.

J. B. Sannes in his pamphlet "The Little Practical Adviser on Kitchen Gardens" analyses bulbs and leaves, and states the plant foods removed by a harvest of 30,000 lbs., as follows :—

	Nitrogen	Phos. Acid	Potash
Bulbs	80·4	45·0	52·5
Leaves	124·2	15·0	110·1
Total	204·6	60·0	162·6

It is remarkable that we find so much of the Nitrogen and potash in the leaves, whilst the phosphoric acid is to be found to the extent of 75 per cent in the bulbs. The importance of potash and its manurial value is evident from the above analysis, and practical experiments in the field prove this only too clearly.

As usual with root crops, though the analysis of the harvest does not show very much phosphoric acid present in the out-turn, a large amount of phosphatic manure is considered necessary by farmers. The nitrogen and potash are supplied in manures and fertilizers according to the analysis shown by the crop, but the phosphoric acid must be present far in excess of what, to judge by the analysis of the harvest, the crop actually demands.

The calculations of the plant-foods removed differ considerably. In this case it is advisable to supply, at first, considerably more food than the plants require for a bumper crop, and by degrees lessen the amounts, changing one of the constituents of the manure, at a time, till the best paying combination is ascertained.

Naturally, much depends upon the source of nitrogen as a manure. Well-rotted stable manure does not give up all its constituents in the first or even in the second year, and it would, in consequence, be unwise to restrict ourselves to the supply the analysis shows. Besides, much of the nitrogen which is not taken up by the plant is lost in the drainage: but as large supplies of cattle manure, when not thoroughly rotted, bring about the ravages of onion maggot, it is advisable not to supply all the nitrogen from this source, but to add more than a sufficiency by the use of other nitrogenous fertilizers As in many other instances, we know from analysis and from experience that farmyard manure, though a complete fertilizer, is not well balanced for this special crop, and therefore advise a smaller quantity of such supplies and an addition of the necessary ingredients for a well-balanced complete plant food in the shape of artificial fertilizers, or there well be a great waste of nitrogen and, perhaps, no trifling deficiency in potash. In order that trials may be started and continued for some time on a small scale till experience has taught the farmer to place complete reliance on commercial fertilizers, or a mixture of these with cattle manure, we give below a few examples of experiments carried out in other parts of the world. To begin with, let us take trials made by English farmers on as small a scale as a perch or pole, namely, $\frac{1}{160}$ of an acre or $30\frac{1}{4}$ square yards, or roughly, plots 6 by 5 yards.

At Southwick, Wilts, in 1902, on a clay soil,

	Manure per perch	Yield per acre
1.	No Manure	5 pecks
2.	Dung I cwt, and Superphosphate 3 lbs,	7 pecks
3.	Dung I cwt, superphosphate 3 lbs, plus sulphate of potash 2 lbs	12 pecks

At Darsham, Suffolk, Mr. George Sudbrooks manured two perch plots with stable dung in the autumn of 1902 and later on used artificials on one of the plots. The crop in 1902 was:—

Manure per peck	Yield per perch
Dung only	6 pecks
Dung, Superphosphate 3 lbs, plus Sulphate of Potash 1½ lbs.	8½ ,,

and in a note of the report he adds:—"The tops of the onions not dressed with chemicals mildewed during the latter part of the season, when the tops on the chemically manured plots were green. The onions on the latter plot continued growing for a longer period, and when harvested there were no picklers."

That a fair crop can be obtained without the use of cattle dung is evidenced by the results of experiments carried out on the Hadlow Experiment Farm with winter onions:—

Manures per acre	Yield per acre
Nitrate of soda 4 cwt.	
Superphosphate 6 cwt.	9 tons 2 cwt.
Sulphate of potash 1cwt.	

In such a case it does not pay to leave out one of the principal plant-foods either as a matter of economy, or because the soil is considered rich enough in that particular food ingredient. On a plot adjoining the one above, the harvest was :—

Manure per acre	Yield per acre Tons	Cwt.
Nitrate of Soda 4 cwt. Superphosphate 6 cwt.	4	13

It is pretty evident from the resulting crop that the soil needed potash in an available form, or the mere addition of 1 cwt. of Sulphate of potash, which is less than is taken by a heavy crop, would not have made so great a difference in the harvests. When cattle dung alone was used on this farm, 12 tons of the manure produced 7 tons of onions, while 25 tons increased the returns by 1 ton 11 cwt. only.

But, where commercial fertilizers were used with cattle dung.

	Average for 4 years
12½ tons dung, plus 4 cwt. Nitrate of soda, 6 cwt. Superphosphate, 1 cwt. Sulphate of potash.	Produced 15 tons 3 cwt.

It is seldom that the raiyat attempts to grow so costly a crop as onions without manuring the previous crop.

Even when a fair allowance of well-rotted cattle manure has been applied to the previous crop, the addition of commercial fertilizers will repay the farmer, and, when these render the plant-food complete and well balanced, they often double the harvest, as we find in an experiment at Calne, Wilts, where Mr. G. Smart made an experiment on loamy soil. No manure was applied for the onion crop, but the previous crop had been treated with dung, with the following results :—

	Per acre
1. No further manure	12,160 lbs.
2. Same as the above, plus 320. lbs. Nitrate of Soda, plus 320. lbs. Basic Slag.	17,600
3. As No. 2 plus 240 lbs Sulphate of potash	24,000

In a report of the manurial experiments of Karl Broeking's Market Garden in Vorhalla a. Ruhr, the chief gardener, M. Roethgens, records a trial on a small plot, the result of which, translated into an acre harvest, ought to induce the Indian cultivator to start upon similar trials. He says :—" In order to ascertain the working of artificial fertilizers on onions, I chose two plots, each 10 square metres (roughly 12 sq yards) in size and manured them alike with cattle dung. Besides this, one received artificial fertilizers at the following rate per acre, Basic Slag 4 cwt., 40 per cent. Potash Salt 1½ cwt, and Chilisaltpetre (Nitrate of Soda) 1 cwt.

The plot treated with the addition of artificial fertilizers showed a denser and more luxuriant growth, while on that treated with cattle dung alone, the little onion shoots were very backward owing to the hot weather, and the greater part of them became yellow. At the same time those in the plot on which artificial fertilizers were used grew strong and were able to resist the drawbacks of the weather.

From the plot treated with artificial fertilizers I obtained onions that sold for Rs.4-8 against Rs. 1-13 from that manured with cattle dung only.

This works out for the acre Rs. 720 as the value of the onions obtained from cattle manure and Rs. 1,800 as the price of that where fertilizers were added.

It seems scarcely necessary to add anything to the foregoing by way of showing the benefits to be derived from a well-balanced complete fertilizer.

But there is a further advantage to be derived from the addition of a complete manure to the 8 or 10 tons of well-rotted cattle dung.

To prevent harm done by onion maggots, market gardeners frequently use Bordeaux mixture, etc., sprinkled on the plants and lime, strong doses of liquid manures, etc., to destroy the young maggots by the caustic action of the materials used.

J. B. Sannes, the well-known Horticulturist of Aerschot, accordingly tried various fertilizers as both insecticides and manuring agents and drew the following conclusions :—

1. Without manure the crop was totally destroyed.

2. Using 10½ lbs. of Nitrate of Soda, the harvest per acre (about 120 square yards) was 670 lbs. but very many plants were destroyed.

3. With 10½ lbs. Nitrate of Soda, 13⅓ lbs. of superphosphote, 800 lbs. resulted : but in this plot also many of the plants were ruined.

4. By adding 10½ lbs. Sulphate of potash to the above manure, the onion maggots were so destroyed that only a few plants suffered and the harvest was 1,340 lb.

So that the complete manure containing potash acted in two ways, destroying the principal enemy of the crop and considerably increasing the returns. To this may be added the remark of M. L. 'Abbe Vander Schueren of Alost that onions raised with the aid of commercial fertilizers are more eas ly preserved and less liable to sprout in keeping.

In a land where cattle dung is so poor and so scarce, it is good to bring to the notice of the farmers other fertilizers, which may enable him to spare some of his farmyard manure for the much neglected land that bears dry crops, and at the same time increase his harvest and the monetary returns from it.

We therefore suggest trials on a small scale with oil cake as well as other fertilizers as an addition to the cattle manure and when these pay by returning an increased and healthy crop, to attempt field experiments, till, in course of time, no raiyat will think of raising a heavy crop only to let the land lie fallow for a long time, or to starve the other fields for the sake of a bumper garden crop.

We have seen that excellent crops of onions can and are grown in India and that when manure is not used it is scarcely due to ignorance, but generally results from want of means. We know also that a farmer who obtains the necessary money spends it as a rule on manures for his garden crops. These few pages are not meant to teach the farmer anything of tillage in which there is little worth knowing that he is not aware of : but our aim has been to show the raiyat that there are many other fertilizers that can be added to a smaller supply of cattle dung than is now used, in order to produce as good crops as he is accustomed to and more paying ones, thus enabling him to save from gradual depletion the lands under dry crops. These last if treated annually with a few tons of cattle manure per acre saved from the garden crops, would give a far better return and rescue the farmer from much of the misery and debt in which he finds himself hopelessly sunk.

We presume the day is not far distant when co-operative loan banks will be scattered over the country and the possibility of obtaining money at reasonable rates will raise the Indian peasant from his state of apathy and despair, to a hard-working and enterprising farmer, as has been the case during the last thirty years amongst the most poverty-stricken and debased cultivators of many parts of Europe, who were in despair till the Land Banks removed them from the clutches of that present necessary evil, the money-lender.

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