

SOIL MANAGEMENT

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Two general policies have been adopted in regard to the management of the soil. Before the war many of those who went out from the older to the newer countries were aiming frankly at soil exploitation. "Get what you can while you can" was the motto, and while the policy brought in money to some of the pioneers, it has in many places ended disastrously. The other method was to aim at permanent productiveness; to study carefully the fertility of the soil and do nothing which would tend to destroy it. This was the policy of the older English agriculturists, and it goes back to the old feudal times when the land was regarded as the one permanent asset, and the family as the permanent possessor. Modern experience shows that permanent fertility is possible, and that a sound system of management will enable the earth to yield its increase perpetually. The top soil can go on being productive indefinitely, unlike the mine which, once used up, is exhausted for ever.

There are several essential conditions for permanent fertility. First of all the soil must remain where it is. Of course it may be levelled or terraced but speaking generally it must remain in position. The idea seems obvious enough to an Englishman coming out fresh from experience with British agriculture, but it would have been recognised as very important by the old Roman agriculturists who were painfully familiar with the problem of soil erosion. Three thousand years ago the Mediterranean regions were forested; then as mankind pushed westwards the forests were cleared leaving a fertile soil; then soil erosion began leaving the land bare and unproductive. Much of it remains so to this day. Meanwhile progressive agriculturists pushed northwards and north-westwards into regions where soil erosion does not usually occur and so the matter was forgotten. It was not till North America was opened up in the 19th century that soil erosion came up once more as a problem, and then it quickly spread and appeared in Africa, India, here in Ceylon and elsewhere.

The whole trouble had arisen from the removal of the natural cover of vegetation and the substitution of a new cover which was nothing like so effective for preserving the soil; in consequence the soil was lost. The reason why soil erosion is not a problem in England

is that natural vegetation springs up very rapidly on uncultivated land and the rain is not intense enough to wash away the soil during the short time that it remains bare. Indeed, the trouble is generally the other way about, and the English farmer is often rather worried by the rapid growth of the vegetative cover and has had to evolve methods of cultivation to eliminate these weeds, as he calls them. The weed problem of the English farmer is thus the counterpart of the erosion problem in other parts of the world; if you don't get one you are liable to get the other.

It is not necessary for me to elaborate this question of soil erosion as you are all familiar with Dr. Eden's valuable summary of the subject issued by the Imperial Bureau of Soil Science in 1933. Ceylon was one of the pioneer countries in recognising the trouble and as far back as 1873 Hooker had drawn attention to the evil results of indiscriminately clearing the forest, which was beginning to cause denudation. The Forest Ordinance of 1885, and the Kelani Valley Railway Commission of 1894 were further stages. But the most important step in Ceylon was the setting up in 1929 of the Government Committee on Soil Erosion which in 1931 issued its Report, now one of the classics of the subject. There are two essential steps for preventing soil erosion. The first is the growing of some crop that will cover the ground and protect the soil against the mechanical beating power of the rain; also the roots of the covering crop help the formation of soil crumbs which are stable to water and therefore resist erosion more than the separate particles would do. Further, the covering vegetation as it dies supplies organic matter to the soil, and this is one of the most important elements in making its fertility. The second essential requisite is the prevention of run-off of rain water; the rain water must be made to soak in, instead of being allowed to run off. Drainage must of course be arranged. The up-and-down planting of bushes so popular with the older planters has to be replaced by a contour planting and where necessary and practicable contour banks are arranged. Elsewhere terraces, bunds, or in bad cases of gully erosion even dams, are erected in regions where land is limited in area and therefore very valuable, as in Japan.

The first essential in soil management is to take the proper steps to prevent soil erosion. It is often difficult to do this in practice because many different bodies may be concerned, and it may be hard to bring them together and harder still to get them to act quickly. But without prompt action when erosion first begins the trouble may go to great lengths and cause very serious losses.

Another important item in soil management is to ensure a full supply of plant food in the soil. The crop takes out nitrogen, phos-

phate, potash and other elements. The older British agriculturists were very afraid of this process, fearing that the constant cropping would exhaust the soil of plant food and so leave it sterile, and unable to carry any more crops. There was never enough farmyard manure to give to all the land, and a variety of other substances, bones, etc., were used in the old days. The introduction of artificial fertilizers nearly 100 years ago as the result of the Rothamsted experiments overcame this difficulty entirely, and the working out of new methods of field experiment by Fisher and Yates on the statistical side, and Dr. Eden and others on the field side, has shown how the fertilizer requirements of crops can be discovered. Dr. Eden has shown the marked need of the tea plant for readily available nitrogen such as sulphate of ammonia, blood meal and ground nut cake, a less pronounced response to phosphate, and still less to potash. When potash is in question the form in which it is supplied is often raised. Our results show that sulphate of potash is slightly superior to muriate on a quality crop like potatoes in production of both yield and quality, but the difference is associated with low rainfall and is not likely to affect tea under Ceylon conditions. Indefinitely large supplies of all these substances are available and one need have not the slightest fear that soil exhaustion will ever arise. The manurial problems that now require investigation are those connected with the proper time of applying the fertilizer, the most economical quantities to use, and their effect on the growth of the plant, its reaction to weather conditions and to the attacks of insect and fungus pests, and on the quality of the tea finally produced.

There has been a great deal of discussion as to whether organic manures such as blood, hoof and bone meal, poultry manure, etc. are or are not better than the ordinary artificial fertilizers. They are probably more fool-proof but they are rarely quite as effective as the other fertilizers and usually much more costly per unit of plant food supplied and of crop increase obtained. I have come across a few cases where organic manure seemed to have some special action; in our experiments with Brussels sprouts we occasionally found poultry manure better than artificial fertilizers, though usually it was the other way about. Salesmen sometimes maintain that fruit grown with artificial fertilizers is inferior in taste and quality to that grown with organic manure. The same claim has been made for other products. I know of no definite evidence in favour of this claim, and I am inclined to think the salesman must have been handling some samples where artificial manures had been wrongly used. So far as tea is concerned the problem is, however, one for experimental enquiry. What usually happens in our experiments with barley, potatoes and other crops is that potash tends to improve the quality, though not always very much, and nitrogen

has no effect one way or the other so long as it is used in quantities that steadily increase the crop, but in larger quantities, where the crop increase falls off, the quality may suffer. For English conditions the limit is often 20 or 30 lb. of nitrogen per acre. For tea it might easily be higher.

Farmyard manure is in a special position as it does things to the soil that artificial fertilizers do not. It breaks down to produce humus in the soil, and in the process it supplies the plant with nitrogen. But it is not an economical supplier of nitrogen to the crop. In our experiments at Rothamsted it took about 3 to 5 parts of farmyard manure nitrogen to produce the same effect as one part of nitrogen in sulphate of ammonia. It has many virtues and one would like to use more of it, but unfortunately it is never available in sufficient quantity.

This has led to methods for eking out the supplies of farmyard manure and for finding substitutes. One of the oldest of these is the making of composts. The art is very ancient, and composts were well known to the old Arab agriculturists, and they are described by one of their writers, Ihu al Awar, in the 10th or 12th century. Composts were in the old days used in England when labour was cheap and abundant, and composting by the Adco process is today used in England in gardens and by some market gardens, but not usually on farms because the cost is too high. Indeed it is this high cost that prevents the process being more used; there is no evidence that the manurial value per ton is sufficient to justify much expenditure. Composts are of course very variable both in composition and in action, and they may range from a rich and effective mixture of human and animal excrements with vegetable wastes, down to a poor mixture of old vegetation of little value in the soil. There is no particular virtue in composting, and you get no more out of the heap than you put into it, indeed rather less, as there is always some loss. It is largely a matter of cost, convenience and carbon-nitrogen ratio whether you dig the vegetable material straight into the soil, or make it into compost and dig that in. But the nitrogen is not nearly so effective as that of sulphate of ammonia.

Compost certainly helps to form humus in the soil and this is frequently an advantage, but forking vegetable matter straight in does the same. The problem is essentially one for experiment; it is a question of fact and not of opinion, and if careful costing shows that the price of the material is too high, it obviously cannot be used in a commercial enterprise.

Green manuring is usually a cheaper and more effective way of putting organic matter into the soil, and you are fortunate here in having green manure crops like the dadap and certain weeds that,

if left, act as soil protectors while they are living and as manure when they are dead. This method of selective weeding seems to me to be of considerable importance and one with a good deal of future possibility. A good leguminous green manure is one of the cheapest and most effective ways of adding nitrogen to the soil, and in addition the root action seems to have a special value in forming soil crumbs and so increasing the stability of the soil.

You are fortunate in escaping one of the most serious difficulties of the British farmer — loss of lime from the soil. Just as weeds and erosion are the two counterparts of the soil conservation problem so lime and soil acidity are counterparts of the soil reaction problem. It does not exist for you and so we need not discuss it.

There is another problem, however, which you may not escape so easily. The classical elements of soil fertility, nitrogen, potassium, calcium, magnesium, etc., are now known to be inadequate for complete nutrition of the plant; certain other elements, sulphur, iron, manganese, boron, zinc, copper and perhaps others are required also, though in very small amounts. Their absence is shown by a loss of vigour of the plant, and in extreme cases by the setting in of some definite disease. For some of these elements the deficiency symptoms are now known: deficiency of sulphur caused a yellowing of tea in Nyasaland; deficiency of copper causes the shoots of various trees to die back and deficiency of zinc causes rosetting of various deciduous trees. It is possible that the occasional instances where organic manures produce better effects than artificials may be attributable, in part at any rate, to the supply of these minor elements. The problem is one to be carefully watched.

I have left to the last the question of cultivation, one of the most important items in soil management. Present practices are largely based on the old English and Scottish gardening technique where a good seed bed had to be obtained and where weeds had to be kept down because they competed with the crop, and because they offended the master's sense of neatness. There was no fear of soil erosion or of other losses, and so long as labour was cheap, abundant, and good, the gardens and the show farms were models of clean weeding and tidiness. But it is all so different now, and these standards do not necessarily hold. It is a matter entirely for experiment to determine how far cultivation should go. In our experiments at Rothamsted we have found that cultivation beyond what is necessary for getting a seed bed and keeping down weeds is unnecessary; at best it is a waste of money and may even reduce the crop by damaging the plant roots. We showed this for sugar-beet, kale and other crops. Fortunately Dr. Eden has been experimenting on this subject and will tell us of his results. Here again

it is a question of fact and not of opinion. There arose an idea in the 19th century that cultivation improves the water supply for the plant. This is so, up to a point. You can reduce the run-off and waste of water by cultivation and so improve the soil reserves of moisture, and you can reduce the temperature of soil directly exposed to the sun by loosening the top layer. But the old idea that you must constantly cultivate in order to break up capillary tubes and so stop upward capillary movement of water has had to be given up; it was pretty and attractive, but had little relation to the facts. Our present idea of cultivation is that it serves three purposes:—

- (1) It gives the young plant a good start, and we all know how important that is.
- (2). It keeps a proper balance between the crop that you have planted and the wild vegetation that plants itself.
- (3) It helps in regulating root development, which in turn determines the volume of soil through which the roots can range in search of moisture and food.

But against this, cultivation may damage the roots, and if it is carried out beyond a certain amount it is at best a waste of money and it may even do harm.

All this shows the need for constant experiment to get at the facts and to express them in such a way that the planter can use them. As the economic conditions change and market demands alter, so the problems change, and as long as the tea-growing industry continues so long will it be necessary to maintain a Tea Research Institute with a highly competent staff to deal with these ever-changing problems as they arise. The greater the efficiency of the planters the higher must be the standard of the research workers. You in Ceylon are particularly fortunate both in your tea planters and in your Tea Research Institute. Let us hope this will always be so; it is certainly the best means of assuring the continued efficiency of the Industry on which the prosperity of Ceylon so greatly depends.

DISCUSSION

MR. I. L. CAMERON remarked on Sir John's reference to cultivation as a preventative of run-off and asked if that was applicable to steep slopes such as those met with in Ceylon. He would also like to know whether the broadcasting of inorganic fertilizers without forking or burying would enable fertilizers to penetrate to a sufficient depth.

SIR JOHN RUSSELL replied that as regards run-off, he thought cultivation was necessary in order to loosen soil sufficiently to allow the rain to soak through. Some sort of drainage would have to be arranged, and the proper type would be determined by observation and trial. Continuing, he said that the question of how best to get artificial fertilizers into the soil was always a problem. Without dogmatizing about tea, he could say that in the Rothamsted experiments they found that the best results accrued when the manures were well incorporated in the soil. Top dressings of soluble fertilizers could be used because they washed down into the soil to some extent. He thought that the manuring programme would have to be related to the programme of general management and cultivation and this included the question of efficient working in of fertilizers.

MR. S. F. H. PERERA said that formerly plant foods were obtained from organic sources, but that the modern tendency was to use mineral manures. He wished to know whether the continuous use of these mineral manures destroyed the tilth and physical condition of the soil.

SIR JOHN RUSSELL replied that on that point their evidence at Rothamsted was of value because it had been a matter of experiment over a longer period than that during which tea had been grown in Ceylon. They had plots which had received quantities up to 800 and 900 lb. per acre of mineral manures every year since 1843, and there was no sign of destruction of tilth. But one could not expect to keep up soil fertility exclusively on mineral fertilizers. They should be used with green manures. He could not recommend a programme of exclusively inorganic manuring but stipulated that organic matter of some kind should be forked in as well.

MR. M. L. WILKINS asked whether exposure to the sun had any effect on soil. He referred to the recent mania for composting prunings, a practice which left pruned areas denuded of cover for at least ninety days. Dr. Harler in a lecture in London in September, 1937 had emphasized the importance of protecting soil against harmful sun effects, but he was afraid his warning had not been sufficiently appreciated. In Ceylon it was common to find pruning and lopping of shade carried out at the same time. He thought it would be better to protect the soil by avoiding simultaneous lopping. He knew of cases where infertile soil had been rendered fertile by protection from the sun.

SIR JOHN RUSSELL asked how the land was protected and MR. WILKINS replied by green manures, leguminous creepers, shrubs and by thatching with any available grass.

SIR JOHN RUSSELL, commenting on the very interesting observation, remarked that he would be glad later to have more information on the subject. The facts about sun effect were rather obscure. There was very little experimental work except Prescott's in Egypt and there exposure was found to be entirely beneficial, but the circumstances were quite different from those in Ceylon. In Egypt there was a certain amount of salt deposited in the soil and Prescott showed that the effect of the sun was to open up the soil in such a way as to allow the salt to be washed out. There was also a partial sterilisation effect which increased the available plant food. On the other hand, in the Sudan the work on sun exposure showed that sun destroyed nitrates in the soil and nitrates were the most readily available of plant foods. In the Fenland in England farmers declared that a summer bare fallow was bad treatment of the soil and reduced its productiveness. The difficulty of getting a decisive answer arose from the fact that when soil was covered it was very likely enriched. For instance a cover of growing green manure was obviously an advantage to soil fertility. To get a definite answer some way of shading soil without attendant fertility effects would have to be used in comparison with bare land.

MR. P. A. KEILLER said that he had read an account of laboratory experiments that claimed to show a definite loss of nitrogen from a block of soil with no vegetative covering, exposed to ultra violet rays. The author made a strong point of the loss of nitrogen from tropical soils owing to sun exposure. In reply to a question, Mr. Keiller said the book was Corbett's "Biological Processes in Tropical Soils."

SIR JOHN RUSSELL in reply said that opposed to this was the work of Dhar in India who maintained that exposure to sun could increase the nitrogen in a soil. The experiments in the Sudan that he had quoted were very carefully carried out, but work of this nature was very difficult to do and when he had visited the Sudan he had found that, notwithstanding the care devoted to them, these investigations were capable of being criticised. This question of the effect of sunlight would be worth taking up in well devised experiments. One thought at first sight that a clean cut answer ought to be obtained, but so far a really critical experiment was wanting. The Tea Research Institute would be a suitable place if the staff had time.