

SOME NOTES ON THE MANAGEMENT OF COCONUT ESTATES IN CEYLON

By T. B. PALTRIDGE

1. Introduction

The management of Coconut Estates is not a subject that can be discussed in terms of any final authority, because there is much that we do not know, and good management on one estate is not necessarily 'good' for all estates. Moreover, the author is acutely aware of his own lack of experience (two years as a Colombo Plan Assignee, working at the Coconut Research Institute), and that any knowledge gained in so short a time would not normally entitle him to write on this subject. However, during those two years a number of observations were made, and may be worth recording; if only as food for thought among those with much greater knowledge and experience of the coconut industry in Ceylon.

With that lack of experience, the author has one advantage in freedom from local tradition, and another that is common to any agricultural scientist who goes abroad and tries to assess the problems of an unfamiliar crop. Such a visitor will see new ways of doing things, and he should be in a position to compare local practices with those that have been adopted and developed in other countries. He can, therefore offer some comment on the *apparent* advantages, or disadvantages, of those techniques. Such comment may, or may not be of value in itself, or it may provide a basis for discussion, with perhaps, some experimental modification of existing practices. It is with that object that these notes have been compiled.

2. The Problem of the 'Manure Circle'

To a visitor from any mediterranean, or sub-tropical country, perhaps the most interesting practice on Ceylon coconut estates is the use of manure circles. These are shallow trenches, dug around the base of individual trees, wherein annual, or bi-ennial doses of fertilizer are spread, and subsequently covered with loose earth. These 'circles' or 'trenches' usually have an inner radius of about 3 feet 6 inches and an outer radius of anything from 5 to 7 feet. They are normally 4 to 6 inches deep. They may have developed from a still earlier practice of tying animals to individual trees and thereby applying 'fertilizer' in a circle.

At first sight this practice seems quite unreasonable, since the coconut tree has a large and spreading root system and each root, as it matures, is enclosed within a cylinder of lignified cells. There are no root-hairs and the absorption of water, or nutrients, is apparently restricted to a short length of young root immediately behind the root-cap. Since root caps are generally located at some distance from the base of a tree, it would appear that the same amount of fertilizer spread evenly over the ground between trees would be more readily absorbed.

This is by no means an original observation, and broadcasting of fertilizers has been tried on many estates. However, as a general rule, and except under special circumstances, the

result has been a decline in yield. On the other hand the efficiency of manure circles has been established on the basis of greatly increased yield, and it is apparent from the much better growth of weeds within those circles.

As one explanation of that effect, it might be argued that preparation of the manure circle stimulates a growth of new and vigorous rootlets, which are in effect a concentration of absorbing root tips in the area involved. However that explanation is not entirely satisfying, and it has been found that the same amount of fertilizer spread on the same area, without digging trenches may be equally effective. Hence there is room for speculation on the reasons why these circles are so effective.

In that connection, it is a point of some interest that in the author's experiments with coconut soils of lateritic origin it has been found that these soils tend to 'fix' a certain amount of potassium. The 'lateritic gravel', for example, appears to absorb a great deal of potassium, and under experimental conditions nearly $4\frac{1}{2}$ cwt./acre K_2SO_4 has been immobilized in that way. With less than that amount, plants of *Paspalum* and *Phaseolus* have suffered from an acute deficiency of K and many have died. On the other hand, a dressing of $4\frac{1}{2}$ cwt./acre K_2SO_4 was generally sufficient to overcome this trouble, and there was no apparent advantage from still higher dosage. In other words, those experiments suggest that an initial dressing of at least 4 cwt./acre K_2SO_4 is required to satisfy the 'absorption capacity' of this soil, and only potassium in excess of that amount would be available to plant roots.

If that is so, then it can be shown that where trees are given 9 lb. of a 3.3.3 fertilizer mixture (e.g. $(NH_4)_2SO_4 + KCl +$ 'Saphos' Phosphate), and if there are 70 trees per acre, then the same amount of fertilizer broadcast over the whole area would be equivalent to an overall dressing of something less than $2\frac{1}{2}$ cwt./acre K_2SO_4 :—i.e. about half the amount required to satisfy the 'absorption capacity' of this soil. It follows that very little potassium would be taken up by the trees, and broadcasting would not be successful.

On the other hand, where that amount of fertilizer is concentrated in manure circles, the rate of application *within the area of any circle* would be approximately 14 cwt./acre K_2SO_4 , and a very large amount (10 cwt./acre) would be available to the trees. Hence the manure circle would be an effective way of supplying potassium to the tree.

If that is so, i.e. if there is any fixation of nutrients by the soil:—with consequent advantage from heavy applications within a restricted area; then it provides one explanation of the success achieved with manure circles, and a very good reason for applying fertilizer in that way.

On the other hand, it is also a matter of some importance in the author's experiments, that applications of more than $4\frac{1}{2}$ cwt./acre K_2SO_4 did not give any further increment in the yield of *Paspalum* or *Phaseolus*. On that basis and considering only the question of available potassium, it might be advantageous to apply fertilizers in much larger manure circles: e.g. circles with an inner radius of 3 feet 6 inches and an outer radius of 10-11 feet. In that way an optimal dose of potassium ($4\frac{1}{2}$ cwt./acre K_2SO_4) would be applied to a much larger area, and should be available to a greater number of roots. There is, of course, no apparent reason why that area should be in the form of a circle, and application of the same fertilizer to an equivalent area of any shape might be equally effective.

As an alternative to this suggestion one might consider the economics and the practical advantages, or disadvantages, in applying potassium separately and in somewhat greater amounts as a broadcast dressing, and thereby providing available K for all the roots of all the

If that were done, then it might be possible to raise production more rapidly to near-optimal level, and that smaller amounts of potassium would be effective in subsequent years.

Unfortunately the amount of potassium required to satisfy the 'absorption capacity' of the soil in one heavy, initial application would vary from soil to soil, and possibly from one estate to another, and at this juncture no comprehensive recommendation is possible. However, the general principle is obvious, and might be used as a basis for experiment by practical men in the coconut industry.

3. Soils and Fertilizers

A use of 'fertilizers' to promote growth and increase the yield of food crops has been one of the most important developments in the history of mankind. However, our knowledge of fertilizer practice is by no means complete, and there are certain basic principles that need to be re-stated from time to time. Fundamentally our objective is to supply certain nutrients which are required for plant growth, and which are not present, or available, in the soil in sufficient quantity. The nature and the amount of fertilizer needed are determined by the requirements of the plants and by the amount and availability of nutrients in the soil. The amount of any nutrient which is required for plant growth can be determined by chemical analysis and by physiological study of the plants concerned, but the nutrient status (i.e. the amount of any nutrient available in the soil) is frequently a matter of much greater importance in determining correct fertilizer practice. In other words it is *not* sufficient for us to say that a given crop required N.P. or K. It is essential to know what amounts of N.P. or X are required for satisfactory growth of that crop in a given soil. It follows that what may be the best type of fertilizer for one type of soil, will not necessarily be correct, and may indeed be quite unsuitable for use on another type of soil.

This problem of soil variation is universal, and it would be quite impossible for any Research Institute, in the present state of development, to make detailed recommendations for every type of soil on a large number of estates. Fortunately, however, the soils of Ceylon fall naturally into recognisable groups, or families and it is, or should be, possible to make a general recommendation for each group. Given that general recommendation, there is need for the individual grower to experiment with some variations of the general formula, and so determine optimal mixtures for the soils of his own estate.

Within reasonable limits, any excess of major nutrients (N.P.K. and Ca) is not likely to cause serious damage, but in some cases (notably on the sandy 'cinnamon' soils) a complete absence of one nutrient (e.g. calcium) can lead to serious, adverse effects from the application of other nutrients, and a balanced mixture may be an essential requirement. Also it is well to remember that any use of fertilizers is subject to the law of diminishing returns, and that any excess of one nutrient, or another, can lead to quite disproportionate expenditure in relation to any increase in yield.

Methods of applying individual fertilizers are still a matter for intensive study, and it is of importance that the best way and time to apply one nutrient, is not necessarily the best; indeed it may be quite the wrong way to apply another nutrient. For example, on 'lateritic gravel' it is now apparent that light dressings of potassium would have little effect on plant growth, and that the best practice would be to apply one initial heavy dose (i.e. 4½ cwt./acre K_2SO_4), which might be followed by somewhat smaller doses at intervals yet to be determined. On the other hand, the use of heavy initial dosage would be quite the wrong way in which to apply

nitrogenous fertilizer (e.g. $(\text{NH}_4)_2\text{SO}_4$, or NH_4NO_3), and indeed it would involve a very heavy loss of available nitrogen through leaching and the liberation of ammonia, etc. In point of fact the most efficient way to apply nitrogenous fertilizer would be in very small and frequent doses.

Other nutrients (e.g. P, Ca, etc.) should also be applied in doses and at times that are suited to the particular type of soil and to the prevailing circumstances.

This question of the optimum amount and frequency of application for particular nutrients is of considerable importance in relation to the common practice in Ceylon, which is to apply a standard mixture (usually one containing N, P, K, Ca and S) once or twice a year. Such a mixture applied at any one time, or at stated intervals, could be fundamentally wrong and by no means efficient, either in producing increased yields, or in terms of economic expenditure. On the whole, it seems likely that a better practice would be to apply individual fertilizers at times and in quantities that are in accord with the demand for individual nutrients.

While this would involve some change in current practice, with the possibility of increased expenditure; that difficulty, or expenditure, might well be compensated by increased returns. Application of heavy initial doses would not imply any fundamental change, but frequent application of small doses might present some difficulty. However, that difficulty is by no means insuperable, and on small estates admixture of the appropriate fertilizer with sand, or fibre dust, would facilitate an even distribution by hand. For larger estates there are rotary fertilizer spreaders that will evenly distribute less than $\frac{1}{4}$ lb. $(\text{NH}_4)_2\text{SO}_4$ per square. Here again there is a need for fundamental research, and for some experiments by practical men.

4. Husk Pits

Husk pits are holes dug in the spaces between trees and usually 6 feet \times 4 feet \times 2 feet deep; they are then filled with coconut husks and covered by the loose earth taken from the pits. There are numerous variations in terms of the size and depth of holes, use of alternate layers of soil and husks, and the inclusion of some nitrogen rich vegetation (*Glyricidia* leaves, etc.), or fertilizer.* It is claimed that these pits improve the moisture retaining capacity of any plantation, and that they contain certain nutrients—notably potash—which are eventually absorbed by the trees. Disadvantages are that they dispose of what might be a valuable bi-product (coconut fibre), and that in dry, sandy country the husks take a very long time to decay.

There is ample evidence to show that husk pits *do* trap a lot of water that would otherwise be lost in run-off; and during dry seasons there is invariably a better growth of herbage where husks have been buried. However, it is rather an open question whether this is due entirely to the husks, or whether the same amount of water could be trapped in any open pit of comparable size and shape. An open pit, would of course, allow free evaporation, and it might be a disadvantage in dry weather. However, it is again open to question whether a pit filled with any other material, e.g. loose earth, or even fibre dust (of which there are large dumps in all parts of the coconut country) would not be equally effective in conserving water. A mixture of fibre dust and soil, for instance, might be almost an ideal moisture absorbing medium.

*It is however, worth noting that this material (husks) has, a very wide C/N ratio, which is not conducive to bacterial growth; and that inclusion of leguminous foliage, nitrogenous fertilizer, or cattle manure, in husk pits may be desirable, since that would encourage bacterial growth, and so hasten the process of decay.

The amount of potash in buried husks would be by no means inconsiderable, and since that potash is normally absorbed by seedling roots, it would obviously be readily available to the trees. Moreover, if one takes into consideration the potash absorbing capacity of lateritic soils, those husks are likely to be even more valuable, because their potassium is not in direct contact with the soil and therefore unlikely to be fixed.

The contribution of decaying husks to the nutrition of coconut tree is difficult to assess, because it is complicated by other factors that are, in themselves of considerable importance. For example while it has been found that lateritic soils tend to immobilize a certain amount of potassium, still further experiments have shown that this process can be, at least in part, reversed by drying and aeration of those soils. Under experimental conditions potassium deficient soils whereon all plants of *Paspalum* or *Phaseolus* had died, were largely rejuvenated by the simple process of drying and aeration, and thereafter the same soil grew quite healthy plants of both species. It follows that the mere act of digging a pit and throwing up loose soil, would in itself bring about some improvement in potassium status, which is normally attributed to the husks.

The whole question of potassium status in these lateritic soils is extremely complex and, there is a question whether cultivation and sub-soiling would not be equally, or nearly as effective as the husk pit, both in conserving soil moisture and in improving the supply of available potassium.

5. Cultivation

In Ceylon and on coconut estates, the term 'cultivation' is generally applied to strictly surface cultivation on land between the trees. Disc harrows, or a bullock-drawn plough are the implements in common use. That practice of 'scratching' or 'disturbing' the surface soil seems to have few advantages, and it might be condemned on several counts: e.g. it encourages surface erosion, it tends to remove all ground vegetation which would normally provide some insulation against excessive temperatures and drying winds, and it tends to destroy any surface mulch that might provide a suitable medium for bacteria or fungi, or for the many types of soil improving micro- and macro-fauna. Its main advantage would lie in the control of weeds; but that is rather a vicious circle, because land so cultivated is, of itself, an excellent medium for weed growth. The ideal form of weed control is a ground cover of other, and more desirable plants.

Fundamentally, cultivation implies a disturbance of the soil, and this may be achieved in a number of ways, according to the requirements of the particular form of agriculture. On coconut estates, for example, a fundamental requirement is to prevent soil erosion, and to that end cultivation may involve no more than the digging of trenches, and building contour bunds. Cultivation may also be desirable to facilitate the absorption of water during rainfall, and to aerate soils that tend to become unduly compacted. Under these circumstances a deep cultivation, with minimal disturbance of the surface soil, seems eminently desirable; and again, digging of narrow trenches, or use of a sub-soiling plough would seem to be the obvious approach.

Sub-soiling and trench digging have one apparent disadvantage, in that both practices involve a breaking, or destruction of many tree roots. In shallow, sandy soils where there is a high water table, this would be a serious complication, but in that case the soils are naturally absorbent and well aerated so that this practice need not be adopted. On the other hand on upland soils and particularly on the 'lateritic gravels' and 'loams', it is likely that any breaking of surface roots would encourage a development of more deeply penetrating roots, on which

the trees must rely for their water supply during dry weather. Under those circumstances any disadvantage from sub-soiling, or bunding might be more apparent than real, and the overall advantage or disadvantage from this type of cultivation seems well worthy of investigation.

Compacted soils are peculiarly resistant to any infiltration of water, and because there is a large and rapid run-off they are very subject to erosion. Sub-soiling and mulching, or indeed any practice that involves loosening and aeration of that soil are therefore commendable as a highly desirable phase of management.

6. Contour Banks and Trenches

Contour banks and trenches are used for either of two purposes, (1) to prevent soil erosion, and (2) as a means of draining low-lying or water-logged soil. Their success in draining depends very largely on adequate outlets and on 'main drains' that will allow adequate flow to some lower level (e.g. the sea); and such drainage is generally a regional problem rather than a job for individual estates.

On the other hand, soil erosion is almost universal in Ceylon, and it might be said that under tropical rainfall level, non-eroding land is virtually non-existent. It must also be remembered that soil erosion is a natural phenomenon, without which there would be no fertile valleys. Complete control of all erosion is (perhaps fortunately) almost impossible, and on coconut estates the problem is to prevent *excessive* erosion.

The construction of adequate and properly designed contour banks is by no means a 'theoretical' or 'hypothetical' requirement. Under tropical rainfall it is a fundamental necessity on almost any slope. Once that is done, i.e. given an efficient chain, or series of contour banks, then a great many cultural practices (preparation of a seed-bed, sub-soiling, broadcasting fertilizer, and grazing, etc.) can all be carried out with impunity and without the usual risk of erosion, or the loss of valuable nutrients in run-off.

Moreover, from current observation and experiments it would appear that the parent material from which many coconut soils are derived (i.e. the cabook, rock, or gravel) is comparatively easily broken down into finer particles (sand, silt and clay) and that in this way there is a constant replenishment, even a build-up, of available plant nutrients; which might account for the surprising fertility and the lush natural vegetation on Ceylon soils. Unfortunately, those finer particles are all too frequently, almost immediately transported (or eroded) and conveyed eventually to the valley floors, where they are thoroughly leached, and many essential plant nutrients are removed. Given adequate protection—by erosion control—these smaller particles should, in time, build up to form comparatively rich, loamy soil *in the place where they were formed*.

In Ceylon, contour banks are generally constructed of loose earth which is taken from a trench dug parallel to that bank. In some cases the loose earth is thrown up-hill (which is the better practice) in other cases it is thrown down-hill and the trenches themselves act as earthenware tanks, wherein run-off water is collected and gradually soaks away. The second method is not ideal, and should only be adopted where loose earth is incapable of holding back any appreciable volume of water.

The fundamental requirements from any system of contour banks are (1) that they should check any flow of water over the surface of the land, and (2) that they should enforce a spread of surface water over quite a large area of land, where it will gradually soak into the soil. Where banks are constructed above the level of their trenches both objectives are achieved, and any soil that is suspended in that water is finally deposited behind the banks. Thus in course of time those hollows will gradually fill up, and the land will form a series of level terraces (see Fig. 1).

Contour banks of this type should be supplemented by shorter banks placed at right angles to the main bank and running up-hill. They should be of gradually decreasing height (i.e. level

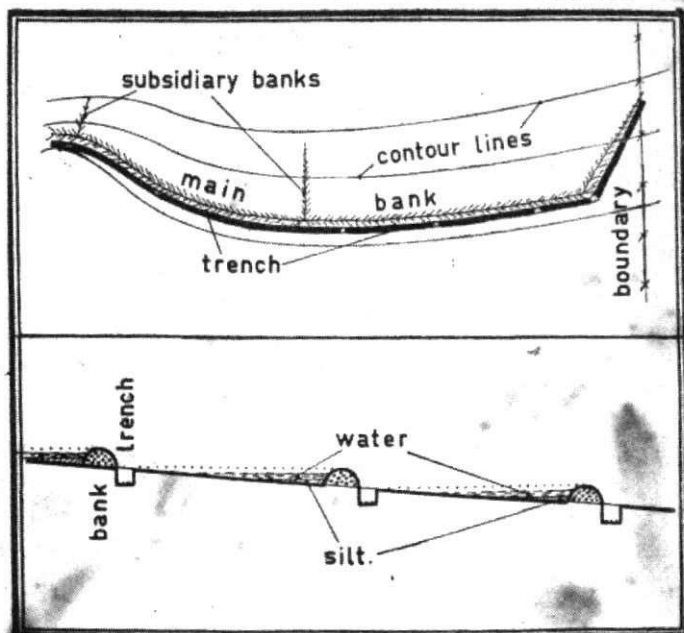


Fig. 1

along the top), and of sufficient length to prevent any lateral flow of water. Also the trenches should have suitable spill-blocks designed and located to prevent any flow of water along the trench.

If, of necessity, the earth from trenches is thrown down-hill, then we are faced with a very different situation, because free-water on the land between banks will inevitably flow into those trenches, and any soil particles in suspension will settle out on the bottom of the trench. Regular cleaning will be essential, and in that process the silt will once again be thrown down-hill. Hence in the long run, this system will encourage an 'assisted' movement of soil from the top of any rise to the valley floor. Moreover, soil from the banks will gradually wash into the trenches themselves and it follows that this system of contour banking will lead eventually to formation of a series of slopes, each somewhat steeper than the original land surface (see Fig. 2).

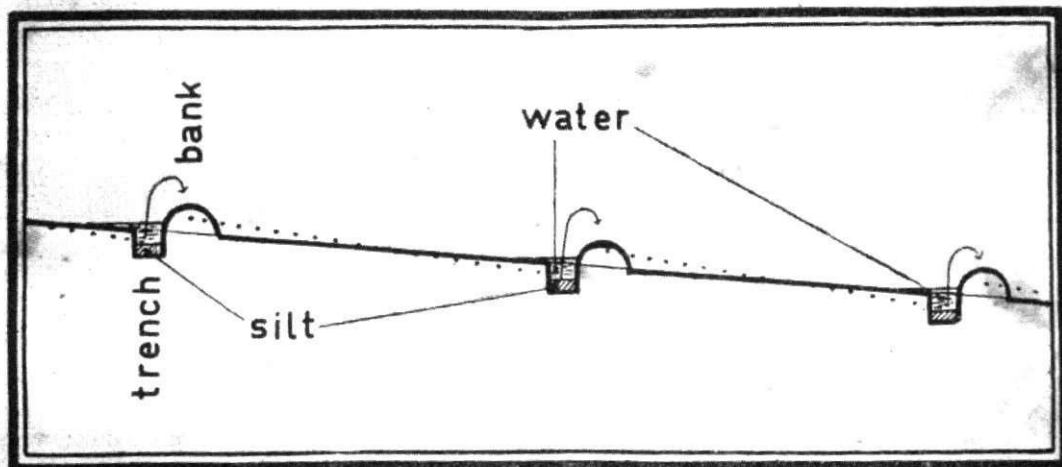


Fig. 2

7. Spacing of Trees

Spacing, or the optimum distance between trees in a plantation is frequently discussed, and it is generally appreciated that the optimum spacing may vary from place to place, according to local climatic conditions. Also it is generally conceded (though not established) that light is an important factor, and that a proper spacing is one wherein the leaves of adjacent trees are virtually touching, but do not overlap.

In this as in many other agricultural problems a basic requirement is to determine precisely what are the limiting factors which control the vigour of individual trees. If for example, intensity, or the amount of sunlight has an over-riding control on growth and production, then undoubtedly the criterion of complete cover, without any overlapping, is basically sound. If on the other hand, rainfall, or the amount of available soil moisture is of greater importance in determining the vigour of individual trees, then a somewhat wider spacing of trees may give a higher level of production. In both cases it is well to remember that any measure of production per tree is not necessarily sound, since fewer nuts per tree from many more trees per acre, or many more nuts per tree from fewer trees per acre, could both give a higher over-all level of production. In point of fact it has been established, with other plants, that where rainfall, or soil moisture, has an over-riding control on production, then within quite wide limits of spacing there is an automatic control of production from individual plants with virtually the same level of production per acre.

Where the limiting factor is *not* basically climatic, e.g. in the case of a nutrient deficiency, it should be possible to increase production by supplying that particular nutrient in the form of fertilizer. Under those conditions, and until some other limiting factor intrudes, any increase in the number of trees would not involve reduction in the yield from individual trees, and the yield per acre should rise almost in proportion to the number of trees. Finally it is well to remember that where spacing is not a matter of critical importance, then other considerations (e.g. convenience in use of implements, or in collection and transportation of nuts, etc.) may well determine the 'ideal' spacing.

A number of arbitrary, or *ad hoc*, experiments on tree spacing will not necessarily yield information that is likely to be of universal application. The fundamental and the correct approach to this problem would be to make a detailed study of limiting factors that are affecting yields per acre, or the yield from individual trees. Given that information then it should be possible both to assess the probable effect of tree spacing, and to formulate some general principles that might be used as a guide to field practice and experimentation.

8. Pastures and Animal Husbandry on Coconut Estates

The place of animals on coconut estates has been a subject for discussion over many years. On the one hand there are those who contend that animals tend to destroy ground cover, and to damage young coconut trees; on the other hand there are those who point to the obvious advantage from animal manure, and the production of meat and milk, etc.

Basically our problem is to decide on the number of animals that can be carried without damage to an estate, and whether the amount of dung and animal products from that number of animals will be economically worthwhile. In both respects this problem tends to become distorted, (a) because over-grazing (i.e. carrying too many animals per acre) is far too common in Ceylon and (b) because production is seldom at an optimal level, because animals are fed on inadequate ration, or they are genetically poor yielders.

The damage caused by overgrazing cannot be too greatly stressed, and it is necessary to break a common fallacy, which argues that because animals provide a 'natural' and efficient filter, in the form of dung and urine; then the more animals we have, the better the supply of nutrients. Basically, any animal must be looked on as a machine which is capable of converting good pasture into good manure, and at the same time producing certain bi-products which are human food, or of economic value. If that machine is deprived of raw materials (stock feed) then it cannot turn out those desirable products with any degree of efficiency, or at any reasonable standard of quality.

A pasture is something that will provide good and sufficient stock feed, and at the same time manufacture and store plant foods (carbohydrates, etc.) that are essential for its own growth. If a pasture is over-grazed, or even incorrectly grazed, then it cannot maintain its own vigour, and eventually it will give way to plants of lesser economic value, or to bare ground.

The optimum, and the correct number of animals for any pasture is that number of animals which can obtain adequate feed (on a year-long basis) without serious detriment to the pasture.

From the point of view of animal husbandry, a pasture is required to provide not only a sufficient quantity of animal food, but also food of the right quality (i.e. a balanced ration) which will allow maximum production of meat and milk, or wool per acre. If the quality of feed falls short of that requirement, then some other type of pasture, or supplementary feed (e.g. *poonac*, and/or mineral licks), must be provided. That requirement is not the same for all types of animals (e.g. milking cows require more protein than dry stock) but some reasonable approximation to correct feed is a first essential to any correct assessment of economic returns from any class of livestock.

As with the animals, a pasture cannot be expected to produce a maximum amount of good quality stock feed unless the pasture itself is receiving adequate amounts of plant food. Moreover, the type of pasture plant that can be grown, and the quality of stock feed thereby provided will be determined by the amount of available soil moisture, and by the supply of available nutrients.

If, for example, the soil on any estate is deficient in any one, or more plant nutrients (e.g. if it is deficient in phosphorus), then the only plants that can be grown successfully will be those with a very low requirement for that particular nutrient, or those particular nutrients. In that event the pasture as a whole will be deficient in nutrients, and either the animals will be unhealthy and unproductive or only a very few animals (i.e. that number which can obtain a balanced diet by selective grazing of young and green leaves, etc.) can be maintained in good condition.

If on the other hand, we supply those particular nutrients in the form of fertilizer, then it will be possible to grow a better type of pasture plant, and to carry more animals in good condition. Much of the food that they consume will be returned to the soil as dung, or urine, and gradually the whole level of soil fertility will rise. Over and above that immediate effect, if we are able to grow a good type of pasture, then those plants will take up other mineral nutrients from the deeper layers of the soil, and they in turn will be transformed into plant tissue, eaten by animals, and eventually returned to the soil in a readily available form. Hence a good pasture which is properly grazed should, in time, improve both the physical structure, and the nutrient status of the soil. It will also tend to check erosion, and to facilitate penetration of rain-water; it will protect the soil surface from insolation and strong winds, and it will provide a mulch wherein a soil improving *biota* can live and multiply.

On coconut estates, any improvement in soil structure and fertility would be a main objective, and any economic return from animal products rather a secondary consideration. However, if we are to attain a high level of soil fertility through animal husbandry, obviously it will be desirable to carry an optimum number of animals in good condition. To that end, we must use fertilizer, and if that is to be an economic form of management, the pasture must pay for itself in its own right. In other words, an efficient type of animal husbandry will be essential to the use and *evaluation* of pastures on coconut estates.

If in addition to meeting that requirement any form of animal husbandry can produce additional returns (i.e. income over and above the cost of its establishment and maintenance) then that income would represent additional profit from the land. Moreover, when the price of copra, or other coconut products, is low, the animals would tend to cushion any serious reduction in overall income.

In certain respects—notably in attempting to provide sufficient and continuing amounts of nitrogen for any crop—and with the exception of green manure (which does not give any direct economic return)—a use of pasture, and stock, would appear to be the only satisfactory and reliable way of providing adequate nutrition for the trees. Moreover, and provided that the pasture pays for itself, this would still be true even where the pasture itself requires nitrogenous fertilizer.

The question of any competition for soil water or plant nutrients, as between the pasture and the coconut trees, is one that cannot be answered at the present time. It can only be answered by experiments wherein the yield of trees grown in association with a well managed pasture can be compared with that of trees grown under any other form of good management. On *a priori* grounds, and from general observation during the past two years, the author is of the opinion that in event of such competition, and provided the pasture does not include a high proportion of undesirable grasses or weeds, then it would be the pasture rather than the trees that would suffer from such competition.

9. Conclusion

In submitting these 'notes on the management of coconut estates', the author is conscious of the fact that few, if any of his suggestions can be supported by experimental evidence, and that without such factual data, any one, or all of these ideas may be ill-conceived, or misleading. Be that as it may, these suggestions are offered for what they are worth, and in the hope that they will stimulate thought and discussion, with some general experimentation along lines that may increase our knowledge of coconut culture.