MECHANISATION PROBLEMS ON COCONUT PLANTATIONS

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Tillage

THERE is unfortunately very little research data available to indicate exactly what form of tillage would be most suitable on a coconut plantation. Various planters and visiting agents have their own ideas on this matter but few, if any, of these are based on scientific investigation ; rather are they practises which have been handed down from one to the other. Where the source of power to perform these tillage operations was supplied either by the estate labourer himself, with a mammoty, or by the buffalo drawing a plough or harrow, not much damage could be caused as depth and frequency of tillage were thus naturally limited. With the advent of mechanised power however it is certainly becoming clear that blind application of the older practises—with the exception that the tractor now replaces the buffalo—is going to result in considerable trouble in the future, and the tractor will be blamed, not the planter who misapplies it !

The reason for tillage has never been very clear, and indications are that it probably originated as a practise for keeping down the undergrowth around the palms. There was also the possibility that the organic matter thus turned in would help improve the structure and humus content of the soil, quite an important feature in our tropical soils which suffer so much from oxidation of organic content at the prevailing temperatures. Another probable reason for the cultivation operation is to break up the mat of roots caused by grasses, etc., on the surface and aerate the soil around the coconut roots—an action which is believed to help stimulate the growth of new feeder roots from the palm, thus invigorating it. There is probably a lot of sense in this contention particularly when we realise how very sensitive the coconut palm is to " wet feet " or stagnation of any form around its roots. The aeration process probably helps release the stagnation to a certain extent. It is certainly a pity that there is still no clear cut research data on this subject of the most suitable form of tillage for a plantation, and whereas we can only attempt to make an intelligent guess as to what constitutes adequate and suitable tillage, there is always the danger that it may be overdone. Already quite a few visiting agents' reports contain the advice "Spread the fertiliser, plough it in with the tractor, and then harrow well to break up the clods and even the ground." This is certainly a practise to be deplored. One feature of tropical soil husbandry which has stood out a mile is that every operation which exposes bare soil to the sun, rain and wind such as ploughing, causes rapid oxidation of its humus content. Further harrowing aggravates this position and renders it very liable to erosion in one form or another. The practice of shallow disc tilling is to be preferred to ploughing, and certainly there is no need to harrow the ploughed land to level the clods. One is not preparing a seed bed in this instance !

One of the best authorities on tropical soils is Dr. E. W. Russell of Oxford who writes, " The practise of applying a layer of dead vegetable waste material such as straw, hay or old grass, composts of farmyard manure, on to the surface of the soil around trees and bushes has been prevalent for a very long time in many parts of the world. These surface mulches can have very important effects on the conditions in the surface layers of the soil, and in consequence on the crops with shallow root systems. Thus, mulching has been widely used for many fruit trees and bushes and for tropical plantation crops with superficial root systems such as coffee and tea.

" A surface mulch has two types of effect on the soil : a characteristic effect, due to it being on the surface of the soil, and a general effect, which it would equally well have if it were ploughed into the soil, due to the plant nutrients set free as it decomposes. The primary specific effects of the mulch are confined to the superficial soil layers, which it keeps both cooler and at a more even temperature, and damper and more permeable to water than the unmulched soil . . . The mulched soil is much cooler during the heat of the day and rather warmer during the night."

" . . . The mulch slows down the rate of evaporation from a bare, wet soil very considerably for the rate of evaporation is controlled by the proportion of the energy absorbed by the soil which is used for evaporating water, and by the rate of removal of the water vapour from the region where it is being produced. So long as the wet soil is exposed to the air, the water vapour is rapidly removed by the general turbulence of the air, but if the water vapour must diffuse through a thin dry layer of soil, or through a mulch which keeps the air almost stationary, then the rate of diffusion limits the rate of evaporation, and this rate is about $\frac{1}{2}$ inch per week instead of one-eighth to one-tenth inch per day for normal hot days. Thus, whereas a wet, bare soil can lose $\frac{1}{2}$ inch of water in three to five days, it takes a mulched soil about six weeks to lose this amount, so that in hot climates a mulched soil can retain against evaporation much more of the water falling as rain than an unmulched."

" . . . The mulch also keeps the soil surface permeable. Rain-water can only reach the soil surface as a gentle stream of clear water, which causes a much smaller drop in permeability than if the soil surface itself was exposed to the beating rain. Thus the mulch reduces the run-off of the rain and consequently reduces the amount of soil the water can carry away and increases the proportion of the rain water that percolates into the soil. Thus, not only is evaporation from the surface of the mulched soil reduced, but the amount of water infiltrating into it is increased. Hence, the water supplying power of a soil can be considerably increased by mulching as is well illustrated by some of S. M. Gilbert's results on the mulching of coffee with banana leaves in Moshi, Tanganyika . . . The effect was large enough for the trees to be wilting on the clean weeded plots, but growing well on the mulched plots, at the time the first samples were taken."

" . . . A further effect of mulches is that they increase the amount of exchangeable potassium in the soil, although the reason for this has not been established. Thus, I. W. Wander and J. H. Gourley found that it was increased considerably to a depth of 8 inches in two years under a heavy straw mulch, and to a depth of 24 inches in twenty to thirty years. In the latter examples the soil under the mulch contained about 490 parts of exchangeable potassium per million of soil to about this depth, but fell rapidly to about a fifth of this value below it, whilst the exchangeable potassium in the unmulched soil fell to this value after a few inches. The extra potassium may have come from the straw, but potassium is the only mineral element showing this strong downward percolation. Further, a grass mulch, made by putting land down to grass and moving it with a gang

FIG. I

The Rotary Mower

FIG. II

The Roller-mulcher

mower, such as is used on golf greens, and leaving the grass cuttings in place, also increases the available potassium in the soil. This method is used in many apple orchards, both in this country and overseas, and it causes the apple trees to take up much more potassium, and also more phosphate, from the soil than if the orchard is kept either clean weeced or sown to annual cover crops which are ploughed in. Hence this extra uptake of potassium, and possibly also of phosphate, appears to be a specific effect of the mulch due to some cause yet unrecognised."

Valuable work has also been carried out on the subject of green manuring by Dr. A. W. R. Joachim and Dr. M. L. M. Salgado whose findings have been supported by research data from other tropical countries. The concensus of opinion appears to be therefore that green manuring does not, if at all, appreciably increase the humus content of the soil, and certainly nothing like as much as farmyard manuring, weight for weight; that green manuring has in most parts of the world been applied more successfully to increasing the available nitrogen supply than to increasing the humus content of the soil; that the green manure should be turned in or mulched at the onset of dry weather in order that it will not compete with the main crop for available soil moisture. If this is not done, the green manure crop will probably do more harm than good; that the nitrifying advantages of a leguminous cover over a non-leguminous one when used as a green manure can only be derived if the cover is turned in just before the flowering stage. This is rarely, if ever, achieved in the case of a perennial leguminous crop as is usually sown under plantation crops.

We may therefore state our objects in soil husbandry in a coconut plantation as :—

(1) A luxuriant cover crop, whether leguminous or not, should be grown.

(2) This cover should be slashed or mown, in order to form a mulch over the soil. It should *not* be turned in through any process involving exposure of the soil.

(3) The mulching should preferably take place at the end of the monsoon rains and before the dry weather sets in. (It may however also safely be undertaken at other times if surface growth is found to hinder other operations such as the collection of nuts).

(4) Occasional aeration of the soil without necessarily exposing it directly to the elements appears desirable and also the breaking of any pan formation for improving porosity (though it is not certain yet how frequently this may be carried out to best advantage, nor the most desirable depth to which it may be economically undertaken).

It thus appears that the conventional plough and harrow have little if any place at all on a coconut plantation. Instead, an implement for mulching would seem to be desirous, together with a sub-soiler, although the latter would have to be used with care until the limits of its benefits are better known. Two implements for mulching are already being experimented with, one a form of rotary mower with a horizontally rotating blade, which slashes surface vegetation, grasses, bushes, etc., and leaves them scattered over the surface. The other looks like an elongated garden roller with blades fixed along its periphery which chops up the surface growth and rolls it down while being drawn over the estate behind the tractor. So far it appears that the latter, referred to sometimes as the roller mulcher, will be most suitable as it even chops coconut branches into multiple short lengths should they be in the path of the implement. The appearance of a field after this roller mulcher has gone over it gives one the feeling that the form of tillage produced thus is ideal for a coconut estate.

FIG. III

The Sub-soiler in raised position for travel

FIG. IV

The Sub-soiler in action

The other implement, the subsoiler has hitherto not been used much on plantations, though it has been found to give excellent results on arable farms. Provisionally experiments are being carried out with two runs of the sub-soiler two feet apart, in the centre of each alternate avenue bi-annually. There is every indication that this severing of old roots and breaking up of crusts will probably encourage the development of new roots, but here too it is an operation which if overdone, may cause very much more harm than good.

In these notes on the tillage and cultivation of coconut soils, I have not mentioned the part which livestock play as I am considering only the instances where livestock for some economic reason or another cannot be kept on the plantation. Certainly, if a good pasture grass is growing on the plantation, and livestock are grazed in rotation over the land, the problem of controlling surface vegetation is then naturally disposed of, and as it can be returned to the land *via* the animals' dung it will be in a form most suitable for improving the fertility of the soil. The dung should preferably be composted or "treaded in" with straw before application with a manure spreader or by cart if such an operation can be kept within economic limits. Otherwise the rotation of the herd through the plantation within the limits of a movable electric fence is quite satisfactory provided the proportions of the herd are just right for the size of the estate, so that no field is ever over-grazed, nor allowed to grow too tall. It is believed that with a good pasture grass the land should take one and a half head per acre comfortably. However, sub-soiling is still probably going to be an operation which will be desirable and will have to be undertaken by a tractor mounted implement.

Fertilising

Once again the insufficiency of research data on the question as to how fertiliser may best be applied to the coconut palm is against us when developing systems for the mechanisation of such operations. We can be guided, however, by certain basic rules regarding general fertilising operation in tropical countries. Fundamentally due to the low organic content of our soils, and the prevalence of heavy rainfall followed by periods of drought, it is best if the fertiliser can be applied in small dosages and as frequently as is economically possible. Thus the practice of fertilising once in two years with, say, an eight pound dose per palm is of infinitely less value than the application of a two pound dose, every six months, and this should be regarded as a standard on sandy soils, with the dosage and period extended to, say, 4 pounds per palm applied annually on gravelly or clayey soils.

The next point to consider is that due to the possibility of rapid leaching, the practice of broadcasting the fertiliser over the broad avenues and subsequently ploughing it in is likely to be very wasteful. Fertiliser should be applied in concentrated "pockets" conveniently near the tree so that it may direct near-by roots into the "pocket" through which to draw a steady supply of nutrients. Should the annual dose, for example, be broadcast over a wide area around the palm, it is likely that by the time the roots reach the fertiliser, it will all be leached down and beyond range. Another important point is that the fertiliser should be turned into the soil, and not just left on the surface where it could lose part of its effectiveness by exposure and also run the risk of being washed off completely during a heavy storm.

One approach to achieve these objects is to fix a fertiliser feed behind the sub-soiler shoe so that a regulated dosage can be incorporated or "injected" into the soil whenever the sub-soiler is lowered into the ground. Thus a ring of fertiliser can be placed around the palm, at say a

FIG. V

The Serrated Disc Harrow

FIG. VI

The Mouldboard Plough

10-foot radius from its base. This however has the disadvantage that it would probably require specialised equipment for regulating the feed to the subsoiler shoe, even though it would probably constitute one ideal solution to the problem, particularly with liquid fertilisers. A more conventional system for use on most plantations is to spread the dose manually in a ring about 3 feet in width and about 10 feet radius from the palm, and then turn it in by dragging a harrow over this area. The reversible heavy duty harrow has been found quite suitable for this function. Should an operator have difficulty going round the palms, the fertiliser could just as well be spread over a strip, say 3 ft. by 8 ft. on either side of the palm and about 10 ft. away from it, for incorporation into the soil by one run of the harrow over the strip. Younger palms would of-course require a smaller dose spread over an even more concentrated area.

Work is already under way to fix a fertiliser spreader over a roller mulcher so that the fertiliser may be applied simultaneously with and just ahead of this operation of mulching. Indications are that this method will probably prove the most practical provided the feed can be controlled from the tractor.

Planting Out

There has been little or no research work whatsoever on the subject of the most suitable size of hole into which coconut seedlings from the nursery may be planted out in the field. The system accepted by most planters was to dig a hole 3 ft. square and 3 ft. deep filled first with two layers of husk and then with soil. There are a great many points against this system, one being that during heavy rainfall the hole becomes water-logged and the seedling invariably floats out. Another reason is that the seedling gets a totally unnatural start in the field. It was in the blind attempt to reproduce this $3 \times 3 \times 3$ hole that the post hole boring technique described on page 147 of the *Ceylon Coconut Quarterly*, Vol. IV, July / December, 1953. Nos. 3 and 4 was devised. However some seedlings were planted out into holes created by just one single bore of the 12 in. post hole borer, each filled first with about 5 husks before topping up with soil. These seedlings are now over two years old and growth in the single bore hole is infinitely superior to growth in all other holes whether of the 4 bore, 5 bore, or $3 \times 3 \times 3$ variety. Incidentally the soil condition here was a very hard, clayey loam, and weather conditions most unfavourable for coconut growing in that the spells of drought between monsoons were very long indeed !

Interesting confirmation of these observations comes from the Rubber Research Institute in Ceylon which has found that rubber stumps (budded) planted into holes prepared only by driving an " alavangue " into the ground for the tap root, grew better than those planted out into carefully prepared holes $2\frac{1}{2}$ ft. square and 2 ft. deep !

Incidentally it was also found best to plant the coconut seedling out when it was about 5 months old in the nursery as by that stage it had not developed too many roots but had sufficient upper growth to indicate whether it was healthy and an early germinator or not.

Draining

A great many of the coconut soils are water-logged and present a constant draining problem. Whereas mole-draining behind a tractor would have been adequate in the case of clayey soils, unfortunately most of the water-logged plantations are in very sandy areas. Surface draining is the only solution. An interesting technique was developed by taking a mould board or disc

plough up and down between the rows of palms, working inwards towards the centre of the avenue, but so to turn the soil outwards towards the line of palms. After about 2 or 3 runs quite a lot of soil is moved upwards from the centre of the avenue towards each line of palms. Thus quite an effective ditch is dug with sides sloping gently from the line of palms to the centre of the avenue, and where this operation has been carried out for two years at six monthly intervals, a height difference of about 4 ft. has finally been noticed to develop between the centre and line of palms. Roots rapidly grew in the area of soil moved up around the line of palms and as this is above the water level in the drain, is most beneficial to the palm.

Husk Burial

This is an interesting fad for which there is once more no scientific support, and is a practice that has developed which can be condoned only during times when the prices paid for husk are very low. The question whether the practice can be justified economically when prices are favourable has never been investigated. Fundamentally it is quite an expensive practice to dig the trenches, let alone place the husks in them, layer by layer of soil and husk. There is no research data to show whether the roots which go into these trenches do so on account of the improved aeration thus produced in the filled trench, or whether they go after the extra potash in the husk, or whether they are just after the water which the pith or dust of the husk conserves. There is further no evidence to relate the quantity of water held by the husk in such a trench in terms of equivalent inches of rainfall over the field. It appears that in so far as the fibres in the husk are better utilised if sold than if buried, it would be better to spread the dust remaining *after* extraction of the fibres over the soil as mulch. The reference quoted earlier in this paper substantiates this contention. It would also be a very much cheaper operation than that of burying the husk, and certainly is far as moisture conservation is concerned just as beneficial, if not more so.

A tractor drawn manure spreader would give very good coverage of the dust mulch, although on a plantation where the tractor is already equipped with a trailer, the trailer can be made to perform this function with the aid of two labourers in the trailer shovelling the dust out as the tractor draws it over the field. A useful point to remember is that the dust is very much better as a manure if first soaked in the waste coconut water from the barbecue.

[The views of our readers on this highly controversial article are invited.—*Ed.*]