SOILS AND MANURES.

COVER PLANTS FOR *HEVEA* PLANTATIONS.

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The following is a lecture delivered by Mr. A. R. Sanderson, F.L.S., at a recent meeting of District Planters held at the Rantau Club. Mr. Sanderson states that great interest was taken in the subject and that an interesting discussion followed the lecture. The question of "conditioning" soils in old rubber appeared to be new ground to the majority of planters present at the meeting.

The subject of cover plants for rubber plantations has acquired constantly increasing interest during the last few years. While the price of rubber was very low cover plants of various kinds were suggested for use as a means of reducing weeding costs, more particularly over immature areas, and in those areas which under the particular circumstances then ruling it was found not profitable to continue in tapping. In the early days of rubber planting clean weeding from the start was the rule and hence one may say that particularly all the old rubber areas have been clean weeded from the time of planting. The only exception to this was the use of various plants usually more or less shrubby species as green manures. Such plants did to a certain extent protect the soil from deterioration due to exposure to the sun but they were far from successful in preventing soil erosion. It may be pointed out here that a plant which may be excellently used as a green manure is not necessarily of much use as a cover plant to prevent soil erosion. For this purpose the best plants are those with a creeping or prostrate habit of growth, forming eventually a complete protective carpet of vegetation. The present condition of, at any rate, some of these older areas has raised grave doubts as to the wisdom of clean weeding. In the present paper I do not propose to discuss covers as green manures.

SOIL FERTILITY.

The fertility of the soil depends on a large number of factors, not all of which always receive the consideration due to them. Certain chemical elements must be present in an available form as plant food and in sufficient quantity to satisfy the needs of whatever crop is cultivated, *i. e.* the mineral constituents of the soil must be such as will enable the plants to complete their normal development without check. In addition the physical properties of the soil—and these are of very great importance—must be such that efficient drainage and adequate aeration is allowed for. No matter how rich the soil is in its mineral constituents, unless the physical properties are good the soil may not be fertile. Climatic conditions must be favourable. It may be mentioned here that for root systems to develop properly aeration is just as essential as for the aerial portion of the plant. This is a point which is not always recognised and it is very closely bound up with efficient drainage, *i. e.*, the passage of rain water from the surface of the soil downwards. The presence of a certain amount of humus in the soil is an important consideration. The conditions mentioned should ensure the presence in the soil, especially the top soil of a rich microfauna and flora which is frequently an index of its fertility, since this is dependent on the three main conditions which govern the fertility of the soil. Any conditions set up in the soil which tend to destroy its indigenous population must then be inimical to its fertility. The soil population (microfauna and flora) is at a maximum a little below the surface (in the top soil) and from that point downwards gradually dwindles and finally almost completely disappears. The depth to which it persists depends largely on aeration, which as before stated is closely bound up with drainage, *i. e.* the passage or rain water through the soil. I think sufficient has been said to emphasize the extreme importance of the physical properties of the soil, as this is concerned with its general fertility. Usually land freshly opened up from virgin jungle is wonderfully fertile containing a sufficiency of mineral matter and humus, and possessing the necessary physical properties. The fact that, at any rate in many cases, it deteriorates, can scarcely be questioned. How does this happen and how can it be prevented at any rate in part?

Casual observation of most old rubber areas and comparison with adjacent freshly opened jungle areas will show at once what a striking difference there is in the *texture* of the soils. To what is this difference due? One, and perhaps the main cause, is the conditions to which freshly opened up areas are or have been subjected.

The land is cleared and exposed to the intense erosive action of tropical rains for a period of 3 to 7 years, the natural result being that long before the plantation can afford sufficient protection, the bulk of the valuable top soil has been carried off to the nearest river. The large seeds, bits of charred wood, small stones, even more or less decayed leaves standing on isolated pinnacles of top soil show at a glance the depth of soil lost. They also indicate how easily this valuable asset could have been retained. That it is a valuable asset to the plantation I think none will question. It contains the largest amount of fertility, the most favourable conditions for bacterial growth and activity. It is the only part of the soil that we can change materially, hence its importance. One of the important chemical elements necessary to soil fertility is nitrogen. The chief source of this is the decaying plant residues (humus material) and the air. In the soil this nitrogen is *fixed*, that is taken up and held by organisms in root nodules of leguminous plants and by certain free living soil bacteria—azotobacter—so long as the land is covered—*nitrogen is gained* and the major portion stored, *i. e.*, the *stock* of nitrogen is increased —it may be but slowly, but still the increase goes on up to a point. Immediately the land is uncovered—*i. e.*, allowed to lie fallow, the gain in *nitrate commences often in a very easily soluble form*, *i. e.*, this represents merely a change of one form of soil nitrogen to another. There is no absolute gain but as you will readily understand, there may be and often is, more especially under tropical conditions of heavy rainfall, a very rapid and serious loss, the land tending to become poorer in nitrogen from the loss of nitrate. It should be remembered too that this element is most expensive to replace as manure. Practically all this nitrogen material is in the top soil, hence the loss of this means the loss of nitrogen also and frequently means the loss of the humus material which should be the basis of future supplies.

E. J. Russel in "Soils and Manures" puts this matter very briefly but pointedly as follows :—

"Land in sod *gains nitrogen*—Land in fallow *gains nitrate*."

From the foregoing it is now easy to understand what happens in the early stage of planting up a newly cleared area with *Hevea*.

Once the land is cleared the *nitrogen* present is rapidly converted into *nitrate* and the young plants do very well indeed, but the pace cannot be maintained for many years. The new crop plus the erosive action of tropical rains rapidly uses up the greater portion of the principal (nitrate) and more is not fixed nor made available at the same rate. A slowing down follows, succeeded eventually by a period of stagnation, for what applies to nitrate applies in a lesser degree to other soluble mineral constituents. The necessity of manures in the form of nitrate is beginning to be realised. If this were the end of the trouble and merely six to eight or even more inches of soil had been removed it would be bad enough, but the exposure of the underlying subsoil to the alternating action of heavy rains and hot sunshine is an added penalty which ultimately strictly limits the soil's fertility.

E. J. Russel writing on the effects of heavy rainfall in *Soils and Manures* states—"Soil exposed to heavy rainfall tends to become reduced to hard insoluble residues of *unchanged mineral fragments, i. e.*, the matter is not in an available form as plant food, finally it may become barren through loss of plant food and sour through loss of lime. Lime is lost chiefly as carbonate. On the other hand a soil in a dry region of very low rainfall keeps practically *all* its soluble constituents intact, indeed it may become so heavily charged with them as to become barren through this very excess, *e. g.*, Alkali lands of U. S. A. Nitrate lands in Chili. Again, heavy rainfall may wash the soil bodily away and leave only the bare rock or a quite impossible subsoil. (This latter is the case most frequent in tropical regions.) It is not infrequent in lands of violent storms, especially *where man has come in and removed the native vegetation that once afforded some—(the only)—measure of protection.*"

The exposed subsoil soon becomes baked hard—in some cases almost cement like, rain water can enter only through occasional cracks, and it may be that 90 per cent. or even more of the rain which falls upon such a surface simply flows off leaving very soon a hard baked surface once more. The failure of the rain to penetrate the soil means that aeration of the soil is insufficient. The soil population is at a minimum, the amount of humus material is negligible. The nitrogen and nitrate content is low—dangerously so. The power to develop fresh stock of this element is non-existent and root development quickly suffers. The result soon shows in a general retardation of development all round. As the plantation increases in age the change for the worse becomes more and more marked, renewal becomes slower and slower, and yields fall off. Different methods—silt pitting, etc.—are then suggested as a desperate effort to improve matters, efforts which at the best can never replace the top soil in its original state.

On flat or comparatively flat lands where there is little actual loss of surface soil by the action of heavy rain and where the drainage is excellent, the soil being porous and easily permeable, the action of uncovering, *i. e.*, removal of original vegetation and keeping it in that state for a considerable time means loss—especially of the more soluble substances. For, as previously pointed out, uncovered land gains nitrate but not nitrogen, *i. e.*, the fixed nitrogen is quickly lost as nitrate and more is not stored.

The whole problem then is one regarding the retention in the main of the original top soil, and keeping this in a state of fertility, *i. e.*, more particularly retaining those physical properties and chemical elements upon which soil fertility so much depends. An effective cover plant is undoubtedly the best method known at present for doing this.

TIME OF PLANTING A COVER.

From what has already been said about soil erosion, it is fairly obvious that the sooner a cover is established the better, *i. e.*, as soon as the land is opened up. It is certainly not wise to first expose the land and then wait one or two years until a part and perhaps the major part of the top soil and its soluble salts have gone. By that time, if a cover is planted it will probably develop much more slowly than if put in while all the top soil was present, hence a double loss will be incurred. The establishing of a cover does not at once dispense with weeding, for lallang will still have to be eradicated. In addition to retaining the surface soil or top soil a good cover will add to the humus content of the soil by the constant decay of the root system, leaf fall, etc. and practically all the mineral matter of the plant is also finally returned to the soil.

I cannot pass over the opportunity to emphasize the fact once more that the primary reason for establishing a cover crop is to retain the top soil and the effect on weeding costs should be a secondary consideration.

EFFECT OF THE COVER PLANT ON THE SOIL.

1. Retention of top soil—this has already been dealt with.
2. Increase of humus—organic matter.
3. Effect of growth and penetration of fibrous roots in the soil.

Regarding the third point, the ramification of the root system of a cover crop—fibrous rooted one—to considerable depths, keeps the soil open and friable—a most important quality for fertility, enabling the quick and easy passage of water downwards.

The arguments so far have been in favour of a cover plant but certain arguments have been raised from time to time against the use of these.

It has been stated that :—

1. Cover crops, since the plants transpire freely, take moisture from the soil and hence actually rob the young rubber plants of moisture.

Of course they take up moisture from the soil, but, and this is most important, they first ensure that a large portion of the rain which falls passes *into* and not merely *flows* over the surface of the soil. It is surely better for the rubber tree to have an ample water-supply and share it rather than have an altogether inadequate supply for itself.

It should be remembered too that during time of drought a reasonably good cover actually conserves moisture in the soil.

2. They harbour obnoxious weeds and increase weeding costs. Some do, but such can be avoided, though again covers must not in general be regarded as a means of dispensing with weeding.

3. Some encourage diseases of rubber.

There is a certain amount of danger from the woody or shrubby ones, the large roots of which persist for a long time but these can be avoided, now that there is a greater choice.

4. The difficulty of eradication is against their use.

This depends largely on choice.

5. There is danger from fire.

This is a real danger with some, but again careful choice should eliminate it.

6. The young *Hevea* plants make most rapid progress in clean weeded areas. Answered under nitrate, c.f. garden plots from grass land.

ESSENTIAL CHARACTERISTICS OF A COVER PLANT.

1. It should be a plant of rapid growth under the particular conditions obtaining, so that it may be effective quickly.

2. Seed should be obtainable in sufficiently large quantities at a reasonable rate. This condition unfortunately at present rules out many indigenous plants which might be useful.

3. If an annual it should seed freely so that fresh crops are continually coming on.

4. It should not be subject to the diseases which attack *Hevea*.

5. The root system should preferably be fibrous.

6. A low habit of growth, so that it can be sown thickly is a desideratum. A ground creeper with roots at the nodes is to be preferred.

7. Ease of eradication or natural dying back when sufficient shade is established to dispense with it is desirable.

Surface mulching should present no difficulty and is preferable.

8. A legume which fixes nitrogen in root nodules is preferable.

9. Care should be taken that (proved by experiment) the plants will develop well under the particular soil and climatic conditions prevailing.

10. Plants easily raised from seed are to be preferred to those which necessitate propagation by cuttings.

CHOICE OF COVER PLANT.

It will undoubtedly not be easy at present to find a plant which satisfies *all* the conditions laid down, but at any rate one can examine the known cover plants about which information is obtainable and pick out what seems to be the best for our purpose.

First I will merely submit a list of the cover plants which have been tried on various rubber growing areas and then deal with each separately.

The following list of species which I don't claim contains all, have been used or are being tried experimentally as cover plants :—

Tephrosia candia "Boga medeloa"
Crotalaria striata
,, fulva
Vigna oligosperma—Sarawak Bean (Dolichos Hoseii)
Centrosema plumieri—Pycon pen
Centrosema pubescens
Indigofera endecaphylla
Calopogonium mucunoides
Desmodium triflorum
,, heterocarpum
,, heterophyllum
,, sp.
Cassia mimosoides
Pueraria javanica
Phaseolus sp.—including Lima bean
Mimosa invisa—giant mimosa
Various grasses
Varieties of peanuts
Passiflora sp.

Some of the foregoing should be avoided unless they are the only ones adapted for the special purpose in hand.

Tephrosia candida grows into a woody bush 1—4 ft. or more in height and requires regular pruning. The persistent thick woody root system is subject to attack by *Poria hypobrunnea* (uncommon in Malaya) which also attacks *Hevea*. This plant is frequently useful on poor soil and will do well under partial shade. As a cover it is far from ideal as heavy rain is apt to cut deep channels between the plants or plant rows.

Crotalarias are apt to grow woody and tall and are subject to Pink Disease on some areas. The same objections hold for this as for Tephrosia.

Centrosema Plumieri fulfils many of the conditions laid down. It is a useful cover (the same applies to Centrosema pubescens). It is essential to plant early to ensure rapid growth and it does not as a rule flourish in poor soils. (Propagated from seed.) Established early it can withstand considerable shade.

Vigna Oligosperma (Dolichos Hoseii) "Sarawak Bean." This is a very useful cover and may be propagated from cuttings or from seed. It grows well in partial shade and can therefore be used or continued at a later stage than Centrosema sp. Like the former it is liable to attack by fungi which cause the leaves to die off and the plants then die back in patches. At present they are being tried experimentally from seed in old rubber. So far it appears to be doing quite well.

Calopogonium mucunoides. According to the *Archief*, May, 1924, this wild leguminous plant was first tried in Sumatra in 1922. It grows in the open and is *not* tolerant of shade. Thinly sown in shallow furrows between two rows of young rubber, the fresh seed germinates *regularly* after a few days, and the plantation is so completely covered within six months by the vigorous growth that *there is no further chance for weeds*—Lallang must be kept out in the meantime. Roots form at the nodes. Flowering begins after 2 months and later the hairy pods develop. This proceeds continuously and produces an enormous quantity of seed. After uprooting, so many young plants quickly develop that the soil is completely covered again within a short time. The plants remain so succulent that there is *no danger of fire* as with mimosa. On all soil types, even sand permatangs, the plant grows vigorously if there is sufficient light. (*Archief Voor de Rubber Cultuur*, May, 1924.)

This plant is being tried experimentally on two neighbouring estates. On one area, where the soil is exceptionally poor the plants appear to be doing well and quite 90 per cent. seed germinated.

Indigofera endecaphylla. This plant forms an excellent ground cover from seed. There is a tendency to die back in dry weather, but vigorous shoots are again put out after rains (tried in Ceylon).

Pueraria javanica. This plant creeps readily and roots at the nodes. It is not so good and thick a cover as Vigna Oligosperma nor as Centrosema sp.

The various species of Desmodium and Cassia mimosoides are at present being tried in Ceylon.

Mimosa invisa requires careful control and is objectional on account of spines, liable to fire in dry weather owing to dying down.

Passiflora sp. unless carefully controlled envelop the young trees and may do considerable harm.

Finally quite a large number of indigenous species of low growing herbaceous plants (creepers) might prove adaptable as cover crops, but only experiments on a sufficiently large scale could demonstrate the utility or otherwise of these.

It would appear that the number of species really fulfilling the major part of the conditions of the ideal cover is strictly limited. Four at present are outstanding, viz :—

Centrosema Plumieri
,, pubescens
Vigna oligosperma
Calopogonium mucunoides.

Once the cover is established it may be continued and indeed should be continued until the shade provided by the developing rubber trees becomes too much for it. Then it will die down naturally or if preferred may be replaced by a second cover established previously which will flourish under a fair degree of shade.

Some agriculturists in Java now recommend the planting of two or more cover plants together. Each cover appears to do better than when grown alone and if one dies off for any reason it is soon replaced by the remainder.

The great majority of covers die off under intense shade, *i. e.*, they die off as covers, but may continue in more or less isolated patches. In any case they have achieved their object and kept the soil in a fine state of fertility.

COVER PLANTS IN OLD RUBBER AREAS.

The establishing of covers on old areas usually presents considerable difficulty. The soil is as a rule totally different in character from that of the new clearing and there is in addition the effect of shade to be considered. Consequently the choice of cover is more limited. Two plants which are said to resist shade very well are Centrosema pubescens and Vigna oligosperma. Of the former I have no experience, but the latter from what I have seen would appear to be worthy of further trials. The method of establishing covers in old rubber adopted in Java is to form a ridge of topsoil consisting largely of leaf mould between the rows and sow the seed in that. Once established the cover then gradually spreads on each side until the cover is complete. Later on if considered advisable this could be mulched in. There is little doubt that the soils in most old rubber areas would be greatly benefitted by this means.

It has been stated that Centrosema Plumieri will continue to grow under old rubber if well established in the early stages, but of this I have no first hand experience.

Experiments with Vigna oligosperma under shade in areas where the rubber is over 20 years old have been started—propagation from seed only. Present indications suggest that this may be very successful.

There are two final covers to be considered, the first being a cover of mixed weeds, *i. e.*, a mixed collection chiefly of indigenous low growing plants, consisting in the main of various small grasses, low growing herbaceous plants, and in some cases small ferns, Selaginellas, etc.

So long as the lallang and bigger plants are kept out, there appears to be little objection to this kind of cover, and its efficiency in preventing or at least limiting the extent of erosion has been proved in some cases.

Concerning a grass cover (not lallang) there is always the proximity of large areas under lallang to be taken into account and the consequent liability to attack by cockchafer beetles. This may on occasion become serious, since once the cockchafer grubs appear in large numbers they do not respect the roots of the rubber plants and may do extensive damage.

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