THE ROLE OF HUMUS IN TROPICAL SOIL MANAGEMENT.*

By

W. B. Haines.

When the composition of soil is examined we find that the most clearly defined division between its constituents is that which classes them into organic and inorganic groups. Both of them represent the products of Nature in that half of her activities which is concerned with decomposing and breaking down. The inorganic or mineral part of the soil is the product of slow age-long processes of weathering of rocks, and has a comparatively simple type of chemical structure. The organic part of the soil, on the other hand, is produced by a much more rapid decay of dead animal or vegetable matter, and it still has the complex chemical structure characteristic of its living period. The much more rapid changes which the organic material undergoes brings it into prominence, for otherwise it is not usually present in large proportion. For the same reason it is only found in the upper layer of the soil, that is, near the region of its source of renewal. The term humus is loosely applied to this soil organic matter. In the later stages of the decomposition, the original organic structure is lost and a dark jelly-like substance remains which has fairly uniform characteristics. The more strict use of the term humus is confined to this end-product.

The unceasing change of the soil humus in its disappearance and renewal as compared with the relatively static nature of the mineral part of the soil, is the main point which it is desired to bring out here. The art of soil management must in the main accept its fate as regards the mineral basis upon which it has to work, the only rapid changes which are to be feared being actual movement under eroding influences. But a very considerable influence may be exercised on the humus status of the soil by judicious or injudicious handling. This is particularly so in tropical climates, where the processes of humus production and decay are so much accelerated. We have to consider the factors which influence these processes.

Let us first recapitulate the important functions which the humus performs in the soil. In the first place it is capable of the release of energy during its process of decay. This is essential for the support of the swarming microscopic fauna with which every fertile soil abounds. These creatures have a very complex world of change and interchange of their own, but their usefulness can be simply stated. They prepare the food material latent in the humus into forms which

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plant roots can again absorb and utilise, and they render available by their manufacture the most important of all plant foods—nitrogen. But without organic material on which to feed, the majority of these micro-organisms can no more function than they could without air or water.

The presence of humus confers very important physical properties on the soil. Being dispersed among the mineral particles it alters their cohesion and makes the soil more friable and easy to cultivate. By its great affinity for water it increases the water retaining power of the soil, so that crops are able better to resist drought. Also, by this improvement in tilth the drainage and aeration are improved, so correcting the harmfulness of the opposite extreme of too much water. In this way humus acts as a buffer, absorbing the shock of two extremes and conserving the useful middle course.

In a chemical sense also, humus acts as a buffer—a word which has come to have a very specific use for an action which at once stores and stabilises. Both useful and harmful compounds can be stored or absorbed by humic material, in the one case saved from loss by leaching and in the other case the bad effect on the soil reaction suspended or nullified. Here again the humus is acting as a valuable intermediary in the soil changes.

The humus probably has other important interactions in the soil which can at present only be guessed at. Suffice it to say that the effects of humus have sometimes been even more far reaching than seems explicable by the simpler facts above cited.

The decay and disappearance of humus is constantly going on, so that from the point of view of the practical man we must consider what balance can be struck by providing for a constant supply. The humus status of the soil is similar to the financial status of a man—a constant steady unavoidable drain on the debit side requiring constant effort to add to the credit side and to maintain solvency. A man's personal banking account does not stand still so long as he remains alive, nor does the humus status of the soil cease to fluctuate according to the changing balance between decay and renewal. This analogy may be usefully developed by the reader to aid in realising the rapid and inevitable change in fertility value of the soil according to the policy of management. Agricultural returns are accompanied by humus consumption, while humus conservation must be at the expense of some outlay or sacrifice of immediate return. On every side one may see in tropical cultivation the soil bankruptcy which has been produced by extravagant management, careless of the future.

Consider first the ingoing side of the balance sheet. Under virgin conditions this consists entirely of the detritus shed by the natural vegetation. This will vary in amount according to the rate of growth, depending mainly upon climate and the basic fertility of the soil. Under cultivation the upkeep has to be attended to. Humus

may be added directly in the form of dung and of some of the organic fertilisers, or it may be added as a green manure crop grown for the express purposes of ploughing in. Although the removal of the crop from the land depletes what would be a potential source of humus, there is a compensating factor in the more rapid turnover produced by cultivation. The efforts spent in producing more vegetation as a crop from a given area tend also to increase whatever part is returned to the soil.

On the debit side the process of humus oxidation and disappearance is incessant. It is influenced very much by climate, and very much by the degree of aeration of the soil. Since the decay is accompanied by the release of plant food, the art of intensive cultivation is usually directed to hasten decay, but the balance must be maintained by increasing the organic input also. Rubber planting cannot be regarded as intensive cultivation in this sense except perhaps for the early period of forcing young rubber into the earliest bearing. Normal conditions approach more nearly the balance of the forest. The curves shown in Fig. 1* will throw some of these points into clearer relief. It represents the two curves of " earning " and " spending " for the soil humus as affected by the factor of temperature. Both curves are seen to rise with temperature until an optimum value is reached, and then to fall off again. The temperature becomes too high in the one case for plant growth which supplies humus and in the other for the bacterial life which destroys humus in the soil. The important thing to notice is that the optimum value for decay is higher than that for production. Since the values concerned are those reached in the tropics this has the geatest importance for tropical agriculture. The effective climate may be much altered by clearing operations, and we can examine what the result will be.

Measurements made at the Rubber Research Institute give an average temperature of 76°F. for the conditions under forest, and 88°F. for the temperature under cleared conditions. These are soil temperatures which may be regarded as the best basis for a discussion of the case. On the diagram are shown the two ordinates for these temperatures. At the lower temperature the rate of production exceeds the decay while the reverse is the case at the higher temperature. This means that in the one case the humus reserve is safe, but in the other is doomed to extinction. It requires nothing more than this to indicate the sudden and complete change in soil history which is brought about by felling jungle. It shows the fundamental process behind the well known deterioration of tropical soils when cleared and subjected to continuous cropping. Without special precautions the humus is bound to disappear entirely.

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*The original curves on which this diagram is based are given by E. C. J. Mohr in "De Grond van Java en Sumatra."

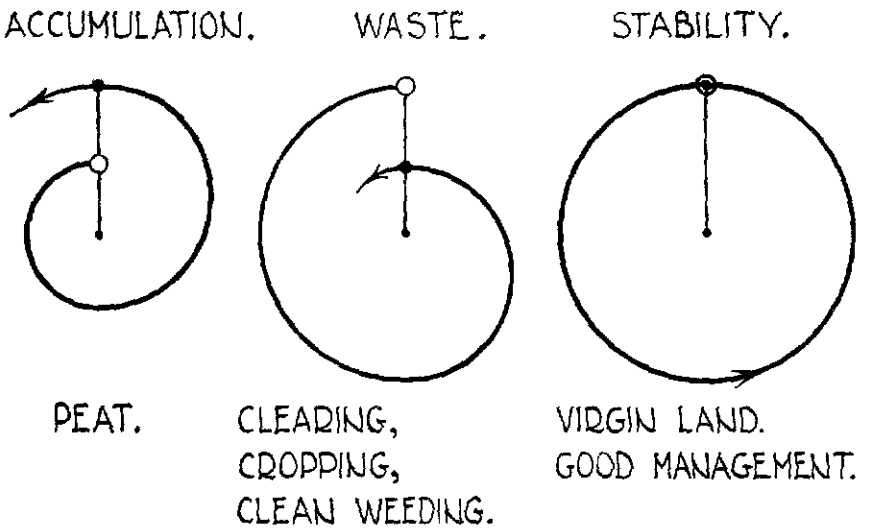
ACCUMULATION.
WASTE.
STABILITY.
PEAT.
CLEARING,
CROPPING,
CLEAN WEEDING.
VIRGIN LAND.
GOOD MANAGEMENT.

FIG. 12

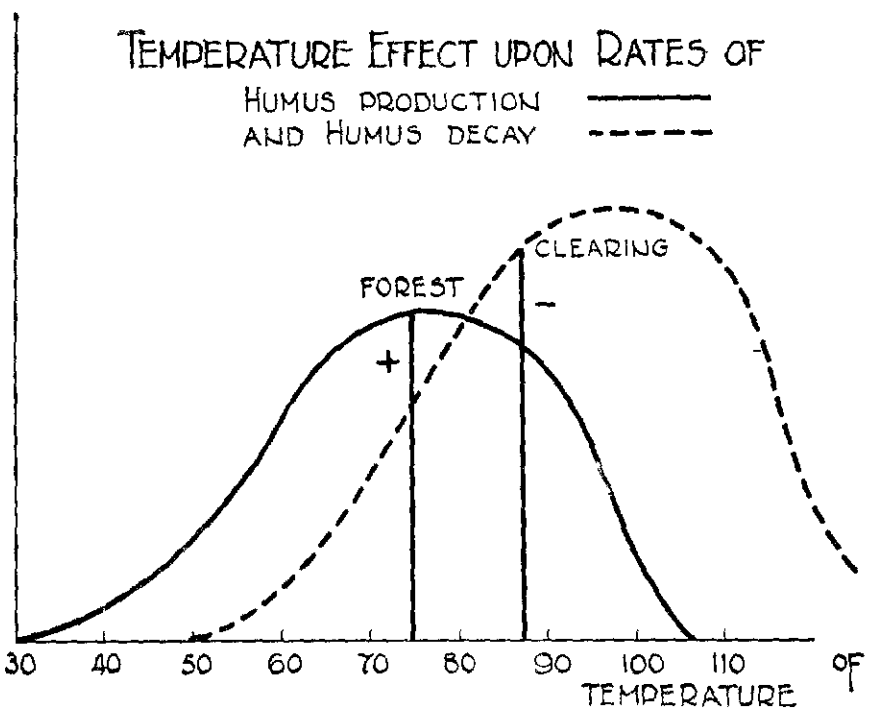
TEMPERATURE EFFECT UPON RATES OF
HUMUS PRODUCTION
AND HUMUS DECAY
CLEARING
FOREST
+
−
30
40
50
60
70
80
90
100
110
°F
TEMPERATURE

FIG. 13

The main precaution possible under the conditions of planting rubber is to reduce the soil temperature by means of a low-growing cover. If the curves can be assumed to be accurate the reduction in temperature produced by a good cover is just sufficient to reach the neutral or balancing point. The reduction in the rate of humus decay, of course, reduces also the release of plant food. This opens up an interesting problem which will take time to solve. Earlier maturity of the rubber can be induced in some cases by the more extravagant cultivation policy of clean weeding, but it remains to be proved whether this gain is worth while in view of the loss of soil capital. It may also be suggested that forcing of early maturity might be less expensively done by means of artificial manures. On a good site where the leaf-fall from the trees regains something approaching the original forest conditions, no great harm may be done by a temporary extravagance, but in other cases it may be a matter of great expense and trouble to make good the humus depletion following clean weeded conditions under young rubber. The falling part of the vegetation curve also suggests that clean weeding might produce temperatures above the optimum value for rubber, so that the benefit from extra food supplies might be lost. This is another point requiring investigation.

We can now translate these main features into a diagram of another type shown in Fig 2. Here the changing humus status is shown by a radius vector which moves round a centre. Rising humus will give an increasing radius and an outgoing spiral. The falling humus of the above clean cleared conditions gives an ingoing spiral, approaching extinction. The third case of stability gives a circle, and the size of the circle will be a preponderating factor in deciding the fertility. The first case of permanent accumulation of organic material arises mainly where excess moisture has depressed aeration and humus decay, and gives rise to peat. The accumulated material sometimes builds up dams which exaggerate the swampy conditions and produce peat bogs. Drainage of the peat at once improves aeration and changes the nature of the case to the second type—an ingoing spiral. This is the danger point to be kept in mind. It means the extinction of the humus unless balance can be restored. On peat lands the process of loss can go on for very long periods without loss of fertility, because of the immense store, but other troubles ensue that are too well known to the rubber planter. The disappearance of the humus results in a fall of the soil level, leaving the roots of any permanent crop badly exposed.

Clean weeding is put down as one of the factors tending to the ingoing spiral, since it tends both to lessen the humus supply and to hasten its decomposition by exposure. In rubber under ideal conditions (where the true forest cycle is attained) this may not be important, since the main crop by its leaf-fall keeps up the humus supply.

But under less favourable circumstances weeding has often greatly hastened deterioration of site conditions.

The third case is the balanced one in which a circle is traced out. This must always be the ultimate case in rubber at any rate and the stable position may be a high or a low one. The aim of good management is to see that the ultimate circle is as large as possible. Intensive cultivation may also aim at making the circle revolve faster, getting a gain on the same principle as a business that makes its capital turn over more rapidly. That case scarcely arises for rubber. All that the rubber planter can do is to seek stable natural conditions under which the production of humus is a maximum and all possible conservation is attained. The main feature is the prevention of surface movement and consequent loss of leaf-fall. A close observation of what happens to the leaf-fall on his estate may well be recommended to every planter as an index pointing to what may need to be done to conserve the humus supply. Where deterioration has gone far the leaf-fall may have become very sparse and recourse may be had to the aid of covers. In one of the best known successful cases mimosa was grown under arrested rubber. The soil changes so induced caused a stimulation of growth in the rubber much greater than artificial fertilisers had done. The normal balance was then quickly attained by the rubber overshadowing the cover, which practically disappeared.