

GREEN MANURING IN RELATION TO ARTIFICIAL MANURING*

T. EDEN.

The suggestion that I should speak to-day on the subject of Green and Artificial Manures involves a very wide field for one lecture. I have therefore narrowed the field of enquiry down to what I believe is the most vital question at present, namely the economical use of both in times of difficult budgets.

We are continually being asked how the manure bill can be reduced without bringing about a lasting deterioration of the soil, and consequent harm to the tea, and particularly whether, in view of the prevailing practice of green manuring, artificials can be omitted entirely. On more than one occasion, it has been suggested to me that the text book idea that green manures provide large quantities of plant nutrients is not strikingly supported by observations spread over quite considerable periods of time. In order to clarify the position it will be necessary for me to describe to you step by step the stages in the process whereby the nutrient substance of green manures becomes available to the plant and to contrast them with the process of artificial manuring.

ARTIFICIAL MANURES: INCOME ON CURRENT ACCOUNT.

To take the simplest case first let us consider the question of artificial manures. A good artificial manure, balanced in respect of nitrogen, potash and phosphate, is, so to speak, a source of income to the soil and the plant. Year by year it is spent more or less up to the hilt, and when the next year's estimates are prepared it is safe to say that most of the manure that has not shown itself in crop-production can virtually be written off as a bad debt.

* Based on an address given to the Dolosbage-Kormale Planters' Association.

This is particularly the case with nitrogen. Phosphate and potash manuring in excess of what the plant is able to use may remain to exert a delayed beneficial effect. If we are speaking in terms of manures which contain from seven to twenty per cent. of nitrogen, the chances of a residual effect under our climatic conditions are small even for the so-called "organic artificials", for even the "organic artificials" are rapidly decomposable into simple forms liable to loss in drainage. In my annual report for the current year I shall publish figures for an accurate experiment which shows that in this year of severe S. W. Monsoon rainfall, nitrogen supplied in the form of bloodmeal has been dissipated as completely as nitrogen in the form of sulphate of ammonia, judging by crop records.

In the light of the foregoing we can look upon artificial manures as being predominating concerned with current account, in which circumstances increase of income is felt immediately or nearly so.

GREEN MANURES: MAINLY DEPOSIT ACCOUNT.

The case of green manures is markedly different and is less easily dealt with. In drawing up a balance sheet for green manures there is relatively little to enter under the heading of income. A leguminous green manure by virtue of the bacteria in its root nodules is able to fix atmospheric nitrogen, and to that extent the green manure taps a real source of income. Nevertheless, although I know of no accurate experiment under tropical conditions from which one can assess this income, there seems little doubt that its potentialities are markedly less than under the conditions of temperate agriculture. From this it follows that a large part of the nitrogen, in all probability the largest part, and all the potash and phosphate, that is built up into green manure tissue comes from the soil reserves.

When therefore green stuff containing say 50 lbs. of nitrogen is forked into the ground it does not supply 50 lbs. of *new* nitrogen; on the other hand when 50 lbs. of nitrogen in the form of an artificial fertiliser is used it *does* supply 50 lbs. of perfectly *new* nitrogen. Before we consider what possible benefit this withdrawal of nutrients from the soil, and out of the range of the tea bush, and its return, can confer upon the tea, it will be well to pursue the subject a stage further. When a green manure crop removes 50 lbs. of nitrogen from the sphere of action it is impossible practically to put the whole of that 50 lbs. back again. The nitrogen is distributed in roots, leaves and woody tissue, but it is not evenly distributed. The concentration of the nitrogen is greatest in the leaves which contain on the average as much as 3%. In the wood the value falls to less than 1%. Since however the trunk of a shade tree remains, and the woody parts of the topplings are discarded, even though they contain

only a small *per cent* of nitrogen, the absolute gross quantity discarded is appreciable, and I doubt whether the balance is ever completely redressed by the income from nodules. Bush and cover crops have an advantage from this point of view because the proportion of woody tissue discarded is less, but the fact remains that there is never likely to be a hundred per cent. return of "borrowed" nitrogen or "nitrogen on deposit" to the soil.

THE RETURN OF NITROGEN TO THE SOIL AND TO THE PLANT.

We must now consider what happens to the green manure when it is forked in, and what share the plant gets of the temporarily hoarded store. The amount which, on decomposition, becomes readily available to the plant depends not only on the quantity of total nitrogen available, but on just how that nitrogen is locked up. I have referred to nitrogen discarded in woody tissues. For reasons that I now outline, it would be injudicious to try and return more nitrogen by using such tissues in addition to the leaves and young stems.

The nitrogen in green vegetable tissue is not immediately available to the growing plant until it has undergone a series of decomposition changes. These changes are brought about by fungi and bacteria. These organisms are not however complete philanthropists; they decompose the vegetation in order that they may live and grow, and they must be served first. It is only what is left after their appetites are surfeited that the plant can use. In their search for foodstuffs the micro-organisms use predominantly two types of food, carbonaceous food such as sugars, cellulose, and starch, and nitrogenous food such as proteins. Their growth in the first place seems to be conditioned by the carbonaceous resources and if that is present in quantity the micro-organisms reproduce themselves rapidly. There is seldom any scarcity in that direction when green manures are forked in. Side by side with their use of carbon is their employment of nitrogen. Sooner or later one of these sources gives out and a period is put to the microbial multiplication. If the carbonaceous matter is exhausted the quicker, all is well, for the excess of nitrogen is then in a form easily accessible to the plant and is so used. If however the nitrogen is exhausted first the organisms turn elsewhere for their nitrogen, and find it in the soil nitrates which normally feed the plant. The result is that the only readily assimilable supply of nitrogen available to the plant is commandeered by the organisms, and is only released when their multiplication ceases and death ensues. This locking up of nitrogen is a well-established fact, and the temporary nitrate starvation it produces can have very serious effects on the crop.

Micro-organic activity can therefore be either good or bad, depending on the relative levels of carbon and nitrogen in the green manure. The critical balance is established when about 2% of nitrogen is present in the buried tissue. Values below that mean that the carbon content is correspondingly high, and no available nitrogen is produced; that in addition, soil robbing may occur. Values above 2% indicate that the processes of decomposition will release the excess over 2% for the benefit of the crop.

It should now be fairly clear that if one considers only one cycle of the whole process, green manures grow, they batten on the soil for supplies to a considerable extent, all that they extract cannot be returned, and of what is returned; only a portion is rapidly available to the crop. It explains why the often quoted statement that the green manure crop supplies so many attractive looking pounds of nitrogen, etc., is definitely misleading, because to reiterate the fundamentals it is *not new nitrogen* and it is not all readily available.

All this seems rather black for green manures but we have looked at one side of the picture only so far. There is the steady inevitable drain of soil nutrients from the soil in drainage losses. Only a proportion of added manures ever produces crop. In a temperate country such as England, at Rothamsted where the rainfall is only 29 inches, it requires 86 lbs. of manurial nitrogen, plus soil supplies, to give a crop of wheat containing 50 lbs. of nitrogen; only 60% of the manure is used, and the rest is a dead loss. Despite all that has been said, it is this aspect of the question that green manures bear on. In so far as they make use of nitrogen otherwise lost in drainage they conserve the soil nitrogen supply; they prevent the waste of income; they recapitalise a proportion of it, some to be decapitalised shortly after burying, some to remain on deposit and make a small but not negligible return almost continuously. So long as that deposit remains intact, locked up with carbon, it cannot be lost in drainage, and it represents a comfortable bank balance on which to draw when normal income decreases, or when adverse circumstances, such as weather, wastefully dissipate fluid supplies. The process goes on continually; always withdrawing, always supplying, always conserving.

The capital supply of nitrogen formerly given for tea culture by the forests of Ceylon is being depleted at a considerable pace by the burning up of soil organic matter by oxidation process hastened by cultivation. The only hope of slowing it down is by green manuring. You cannot conserve nitrogen unless you conserve carbon too. Fortunately the green manure manufactures carbon compounds from the carbon-dioxide of the air. That is the master key to the whole situation.

No more striking confirmation of this is needed than forest soil itself. Before the advent of vegetation there was assuredly little difference in the nitrogen content of different soils. Forest soils have kept their nitrogen because it has been absorbed by the trees, combined with carbon and returned to the soil as leaf mould.

PRACTICAL APPLICATION.

I have dealt at length with the green manure cycle because the aspect I have described is to my mind the most important nutritional aspect in tropical agriculture. In what follows I shall deal with a few selected and specific points.

An estate with a through green manuring programme is husbanding its soil nitrogen supplies and will consequently be in a better position to weather the economic storm. Whilst it follows that the total cessation of artificial manuring will progressively curtail the nutrient supply to the crop, the decline will be less severe than where no such programme is in operation. One cannot recommend the dropping of artificials *entirely* even with a green manure programme; but any curtailment is likely to be of a less permanently harmful nature than in the absence of green manures.

From what I have said, the success of forking in green manures is seen to depend largely on the composition of the green stuff at the time it is used. The older the vegetation used, the smaller its nitrogen percentage composition. Thus to leave a crop to grow to large dimensions may result in a low nitrogen content which was seen to be inadvisable. As a general rule green manures should be lopped before full flowering, as after that the nitrogen is withdrawn to the seed; woody tissue is to be avoided always.

Despite certain practical obstacles there is much to be said for forking in green manures and artificials together. The nitrogen contained in the latter helps to stimulate the vegetable decomposition. If the nitrogen content of the green stuff is unavoidably low it also helps to bring up the general level above that critical 2% and to prevent soil robbing. Even though some of the artificials are thus temporarily locked up they are saved from drainage losses and will come into action later. For a similar reason the use of artificials of an inorganic type in conjunction with green manures raises part of them to the category of "organic artificials" which are unit for unit so much more expensive.

In conclusion, whilst I have purposely avoided any reference to the benefits that accrue from the use of green manures as improvers of the physical state of the soil, that is an aspect of equal importance and is another argument for the prosecution of a far reaching green manure programme.