

SOILS, FERTILIZERS AND THE GROWING PLANT.

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The problem of obtaining the maximum value from artificial manures is one which has become particularly urgent since the decline of the tea market set in. The most satisfactory basis for manurial practice is that afforded by accurate experimentation on tea; but at present there are relatively few data relevant to present needs though efforts are being made by the Institute to acquire them. Nevertheless, there are certain principles of general application that are not so widely understood as they might be, and to them this article will be mainly confined in the hope that they will prove of use practically, and will help in the interpretation of field experimental results as these become available from time to time.

The first general consideration of importance is that of the relationship of soil analysis to manurial practice. This has already been dealt with in the *Tea Quarterly* (Vol. 1. page 97) but a word in amplification will not be out of place here. There is no difficulty in determining accurately the amounts of the various nutrients that are to be found in the soil. Anyone who is interested in such data can obtain it from half a dozen sources without going out of Ceylon. Moreover, the analyses of different analysts would agree. Where unanimity of opinion might probably be lacking is in the interpretation of the results so obtained. What does a given chemical analysis of the soil mean in terms of plant behaviour? Methods for determining chemically that portion of the plant nutrient that is available are admittedly tentative. They frequently fail for two reasons. They may err considerably in their estimate of what portion is useful to the plant, and they frequently give no information at all as to how rapidly the unavailable portion is transformed into available supplies. It is obviously important to know, so to speak, not only how much palatable food there is in the store room, but also how rapidly it can be transferred to the table. As an example of the kind of difficulty met with in actual practice, Greenhill (*Journal of Agricultural Science*, 1930, 20, 560) gives data showing that a series of soils known to differ widely in phosphate content, showed negligible differences in the phosphate content of their soil solution. In actual yield response the plants grown on these soils differed widely, but not in proportion to the total phosphatic supply of the soils.

The foregoing does not invalidate the use of the soil analyses in special cases. Much sound advisory work has been done by combining a wide knowledge of soil analysis with agricultural observation and acumen, or better still with actual field experiments of proved accuracy. In general, however, such work has proved valuable only in special circumstances on well-defined soil types, with a few specific crops. It has been more successful for nitrogen requirements than for potash, and the case of phosphate has been least satisfactory of all.

A way out of this *impasse*, which one hopes may be temporary, has been sought in the analysis of the plant itself, but here again soil analyses and analyses of plants grown on the respective soils do not tally. There is no equivalence nor even a fixed ratio between the amounts of nutrients found in the crop and the amount needed or supplied as fertilizer. By way of illustration, at Rothamsted, winter rain causes a loss of 1.4 bushels of wheat per acre which represents a loss of two pounds of nitrogen in the crop to the plant. It requires eight pounds of nitrogen applied to the soil, however, to make good that damage. Again, the average phosphatic content of the tea crop is lower than the average content of nitrogen or potash: the quantity of phosphate normally applied to the soil is on the other hand greater than the quantities of nitrogen or potash used per acre. In view of the crop analyses it may at first appear a wrong practice to apply such large quantities of phosphate, but experience shows that the utilisation of added "soluble" phosphate is low and never exceeds a 15% recovery of what has been added.—(Russell, 1931, *Artificial Fertilizers*.)

In the face of these inquiries it must be conceded that field experiments offer the best method of judging manurial requirements and that soil and plant analyses should be regarded as ancillary weapons only.

There should be little need at the present time to emphasise the necessity for supplying all the major nutrients in manure mixtures. As far as our knowledge of manurial balance goes, in Ceylon definitely ill-balanced rations seem to be the exception, but in view of financial depression the point may well be stressed that economy in manuring should never be made at the expense of a single ingredient. One nutrient will not work efficiently in the absence of the others. To illustrate this point an experiment may be mentioned in which nitrogen was supplied in the presence and absence of mineral nutrients. Since the plants were grown in pot culture, leaching losses

did not occur, but results showed that the nitrogen recovery by the plant in the pots supplied with mineral manures exceeded that attained in their absence by 50% (Russell, *loc. cit.*).

From the question of balance one naturally passes on to that of the actual ingredients to be used. The phosphatic and potassic fertilizers are simplest to deal with and will be taken first.

Superphosphate—provides a readily available supply of phosphates with a slight benefit in unit price in favour of the concentrated variety.

Basic Slag—compares favourably in unit price with superphosphate, but its real efficacy depends upon its solubility; high soluble slag (over 80% solubility) gives concordantly better results than those of low solubility.

Bone Meal.—In general, experiments have shown that this is not superior to superphosphate either in yield production or lasting effect. Its price range is similar, a slightly higher value being offset by its nitrogen content.

Rock phosphate.—This product, of which Ephos and Safaga phosphates are representative, is the basis for the manufacture of the more soluble superphosphates. It is the cheapest form available and can be obtained at about two-thirds the unit price current for superphosphate. It has been compared under English conditions with low soluble slag, but there is evidence that its performance under the conditions obtaining in Ceylon, viz. high rainfall and acid soils, will be superior to its behaviour in temperate agriculture. It may be regarded as a cheap and valuable source of phosphates.

Muriate of Potash—is undoubtedly the most economical potash salt to use. The saving per unit is about 25 per cent when compared with sulphate and in a rainy climate the possible harmful effects of the chloride it contains are negligible.

Sulphate of Potash.—In comparison with other potash salts, the only distinctive advantage is its better keeping capacity. Muriate if left exposed to damp very readily absorbs water.

ORGANIC AND INORGANIC NITROGEN.

The most debated question regarding manures at the moment is undoubtedly that of the alternative use of organic and inorganic nitrogen. On an average, organic nitrogen costs over two and a half times as much as the inorganic form. At present this additional cost of organic nitrogen becomes a serious item and the question arises whether that extra cost is justified. If there were incontestable experimental results there would be no further need of argument,

but though a good deal of demonstration work has been planned and carried out in Java, India and Ceylon, the results are in many cases contradictory and unconvincing. In briefly summarising these experiments it would not be unfair to say that a case has been made out for bulk manures, but not indubitably for organic artificials.

Three factors which may react in favour of organic artificials are described in agricultural chemical literature: (1) The ameliorative effect of organic matter on soil tilth and microbiological activity, (2) Slow but steady availability, (3) the presence of some stimulating substance akin to vitamin in animal nutrition which exerts an influence out of all proportion to its quantity. The first two deserve serious consideration on their merits. Recent work on the third shows that the quantities required are always present in an agricultural soil even if it is incredibly poor. With regard to the first two points it is well to note that although the text-books of agricultural chemistry refer with one accord to the extensive experiments carried out at Rothamsted, they do not generally distinguish between bulk organic manures and organic artificials. The time is ripe for re-examination of the problem in the light of the Rothamsted results which should clarify the main issue.

The comparison of rape cake with sulphate of ammonia is the only one in the Rothamsted experiments which is relevant to our point. This trial has been made on mangolds grown continuously since 1876. The 52-year averages 1876 to 1928 give the following results:—

Rape cake (98 lbs. N)	21 tons per acre
Sulphate of ammonia (86 lbs. N)	14.4 tons per acre

Here there is a distinct advantage in favour of rape cake, and it may be conceded that the advantage would still remain if the quantity of nitrogen given in the rape cake were scaled down to the level of the sulphate of ammonia. It is a feature of this field that on the rape cake plot the germination is very much better than on the sulphate of ammonia series, and this is reflected in a better stand of plants (even after the thinning out process of "singling") to the extent of between 4 and 5 per cent in 1931, the only year for which such figures are available. The quantity of rape cake applied is two thousand pounds per annum and it is reasonable to suppose that such a quantity supplied annually since 1856 (twenty years before the crop was stabilised as mangolds) has had an appreciable effect on the tilth. Mangolds are particularly sensitive to tilth conditions at seeding and for a considerable time after, and the better stand obtained with rape cake may be taken as an indication that in terms of general robustness of growth the rape cake plots have an undeniable advantage.

Nevertheless, it would be rash to generalize on this basis because of the peculiar nature of an annual crop of this delicacy, and of the very large quantities of rape cake that have been supplied.

This experiment demonstrates the ameliorative effect on soil tilth. If it is held that the increased crop obtained from rape cake shows the superior quality of organic nitrogen, the other side of the picture is shown by a corresponding experiment on barley grown continuously since 1852. For the 76-year period 1852 to 1928 the following averages are obtained:—

Rape cake	(49 lbs. N)	38 bushels per acre.
Sulphate of ammonia	(43 lbs. N)	39 bushels per acre.

There is no superiority shown here despite the six pounds extra nitrogen given as rape cake: nor can it be argued that both plots are over-manured since yields on other plots reach an average of 45 bushels.

This experiment gives no support to a general theory of soil tilth improvement and in addition throws light on the second question that of availability. The small deficiency on the rape cake plot has been a feature of the experiment throughout the whole period, and has not diminished in later years. This indicates that the nitrogen compounds of the rape cake are almost wholly utilisable by the crop to which they are applied. At any rate no large amount of residue slowly becoming available is left in the soil as is the case with farm-yard manure.

Turning to point (2) availability, it is of interest that barley is a crop that is only in the soil for some five months and that its nitrogen supply is garnered chiefly in the first half of its life cycle. In the light of these classical experiments, rape cake which contains 5% of nitrogen only, does not seem to behave as a slow acting nutrient with an appreciable residual value. It has no superiority for one of the two crops studied but has for the other. Its superiority can be linked up with its effect on tilth when applied continuously in exceptionally heavy dressings.

Confirmatory evidence for the rapidity of availability of organic artificials is given by Joachim's work on their nitrification (*The Tropical Agriculturist*, 1928, LXXI, 131.). Confining his attention to primary nitrification i.e. nitrification taking place before any large amount of re-assimilation of nitrogen by microbial organisms is evident, he finds that the maximum for all types of nitrogenous manures is attained in the sixth week. The percentage of original manure nitrified in that time is given (*loc. cit.*) as follows:

Ground Nut Cake	...	86
Blood Meal	...	46
Fish Guano	...	68
Fish Manure	...	79
Cyanamide	...	64
Sulphate of Ammonia	...	47

Allowing for a considerable sampling error which is inevitable, it is not straining the evidence to say that "organic" artificials are as rapidly available and as rapidly wasted as the inorganic salt.

The writer has previously (*The Tropical Agriculturist*, 1928, 70, 310) pointed out that the leaching loss experiment of Joachim points in the same direction.

As field experiments and laboratory trials have failed to substantiate the superiority of organic artificials, how has this conviction of their superiority grown up? We may hazard the opinion that the answer lies in the history of artificial manuring. Organic fertilizers have not always been so much more expensive than inorganic. At a time of high prices when manuring in almost any form was paying, agriculturists were not so interested in the niceties of the inorganic versus organic controversy as they have been of late years. Moreover, in the times of which we speak the balancing of artificial manure mixtures was not so well understood. Many farmers and agriculturists manured solely with one ingredient. The man who used cakes, guanos and offals was, however, *ipso facto* using something in the nature of a balanced mixture since the ash content of these manures is contributing phosphate and to some extent potash. In course of time, in certain seasons he reaped the benefit, and naturally regarded the organic manures as the better proposition. A preference which in one stage of knowledge and under good market conditions may be entirely justifiable may have to be altered when quite different conditions supervene. The essence of the problem is what to do at the present time.

If the foregoing does not prove the case for inorganic artificials, and the writer is conscious that the absence of direct experimental evidence for tea is a serious drawback in the search for finality, it must be conceded that the attendant nutritive risks for yield and general health are at least minimised so long as the colloquially described "gun powder" mixtures are ruled out.

There remain doubts as to effect on quality. Here all that can be said at present is that we have no evidence that quality has suffered from the use of sulphate of ammonia as distinct from organic nitrogen. Cases of deterioration have come to light but in these quantity and ill-balance would fully account for the results. During

the last two years, tea receiving 40 pounds per acre of nitrogen, two thirds of which has been inorganic, has been manufactured separately and compared with similar tea without nitrogen, and no consistent differences have emerged. This is as far as we can take the evidence for and against organic artificials up to the present. A full discussion of the data of the Institute's field experiment will take place at the 1933 Conference when a further year's data will be available.

What are the risks to which the sole use of inorganic nitrogen exposes us? They do not apparently arise from a too rapid availability; are they associated with a certain diminution of organic matter in the soil? Taking a liberal estimate of 500 lbs. of organic nitrogen manure as the annual amount commonly used on tea, this amount in the first nine inches of soil represents only .002 per cent. Such a quantity is a very different matter from 2,000 pounds used annually in the Rothamsted experiment and no one can reasonably compare mangolds and tea with regard to tilth requirements. What cannot be strictly justified on scientific evidence alone, however, may have to be seriously considered in times of depression. The point is that inorganic nitrogen in conjunction with green manuring and the use of tea prunings supplies all the nutrients and organic matter necessary to maintain the tea bush in health, and the soil in tilth, and the use of them is preferable to a cessation of manuring altogether.

Thomson, in the previous issue of this journal, ingeniously presents data regarding the immobilisation of nitrogen by green manures. His contention may have to be modified in view of what has previously been said about availability, and in the light of recent work that, it is only fair to say, was not available at the time his article was written. Richards and Norman (*Biochemical Journal*, 1931, 25, 1769) have pointed out that fermenting vegetative matter even of high nitrogenous content will immobilise inorganic nitrogen in excess of that predictable by the carbon-nitrogen ratio. They demonstrate that the micro-organisms prefer to use ammonia rather than to undertake the necessary decomposition of protein nitrogen in the plant material. In a striking experiment with bean husks which already contains more than 0.5 per cent. more nitrogen than is required for completing the decomposition according to the "adco" process, they have succeeded in immobilising all of it plus a further 0.62 per cent. Willow peelings which already contained 1.9 per cent. of nitrogen immobilised a further 1.33 per cent.

In conclusion, it may be mentioned that we do not consider these questions solved, but since work in the field and factory on inorganic and organic nitrogen has already been in progress at the Institute for two years, any fresh developments as to their cumulative effect that may conceivably occur will be evident before similar developments occur on estates. In the meantime, whilst watching these results with the greatest care, there are sound reasons for adopting the inorganic forms in preference to a complete cessation of manuring whilst depression conditions last.
